

## ABSTRACTS OF PAPERS AND POSTERS 2001 Meeting

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### A GEOGRAPHIC ANALYSIS OF THE GAP CROSSING BEHAVIOR OF MANDRILLS IN A FOREST/SAVANNA MOSAIC IN GABON.

Surprisingly large groups (300 – 600 individuals) of mandrills (*Mandrillus sphinx*) have been shown to use a mosaic of disconnected forest corridors in a forest/savanna mosaic at the Lope Reserve, Gabon. These groups restrict themselves almost entirely to the forest corridors, rarely ranging more than 15 meters into the open savanna. As a result, some islands of forest appear to be effectively isolated because the gaps between forest corridors are too wide for the mandrills to cross. We examined this behavior using a geographic analysis of gap cross distances and hypothesized barriers to crossing, including roads, railroads and swampy areas. Based on over one year of field monitoring, we quantified the sizes of gaps the mandrills actually crossed. We compared these results to a measurement of all possible gaps using a forest / savanna vegetation map interpreted from a 6 m resolution radar image. We showed a distinct preference for gaps less than 110 m and showed that the swampy areas may pose a barrier to crossing, but roads may not. We suggest from these results that selective reforestation or changing the anthropogenic burning regime which maintains the savannas may result in increased habitat for these mandrills.

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### ABRUPT POPULATION CRASHES WITH STEADILY DETERIORATING CONDITIONS IN ECOLOGICAL MODELS.

When gradual changes in environmental conditions reduce individual fitness within a species, simple models suggest that population density may often not change significantly for many years, and then decline precipitously to extinction. The early lack of response to environmental degradation is due to compensatory changes in intra- or inter-specific interactions. Models of simple food webs show what conditions frequently produce abrupt rather than gradual declines in population size with deteriorating conditions. Weak density dependence, strongly saturating consumer functional responses, self-reproducing resource populations, over-exploitation of resources by consumers, and environmentally-caused reductions in consumption rates are the major factors identified with the pattern of abrupt declines in population size. Cycling consumer populations are especially likely to show initial increases in average population sizes, followed by abrupt crashes as the environment deteriorates. These theoretical results call for increased monitoring of parameters affecting individual fitness, particularly in predatory species that greatly reduce their prey.

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### FRUIT FEEDING BUTTERFLY COMMUNITIES IN FOREST REMNANTS AND SILVICULTURES AT UNA, BA - BRAZIL.

Butterflies are regarded as good predictors of diversity and disturbance in forest ecosystems. Here frugivorous butterflies were censused with bait traps at Una, in Brazilian Atlantic Forest. The landscape included interconnected rainforest tracts, silvicultures and pastures. Butterflies were sampled in large and small mature forest patches, forest edges and wooded matrices specified as young secondary forests, shadowed cocoa and rubber tree plantations. Butterfly sub-communities were compared using rarefaction curves, diversity indexes and species relative abundances. 3,704 butterflies of 89 species were trapped. Significant differences were found among sub-communities. The dominant species in mature forests, *Pseudodebis valentina*, is apparently sensitive to fragmentation, being very rare or absent in matrices and small forest patches. Other forest butterflies were able to use small patches and matrices at variable degrees. Forest edges owned greater species richness due to presence of more canopy-clearing individuals and invasion of non-forest, disturbance-adapted species. Such invasion also occurred in wooded matrices, but there were marked differences within species colonization capabilities. Among the matrices, secondary growth was favorable for most butterflies found in mature forest while shadowed cocoa strongly favored small understory species, usually restricted to light gaps. Conclusion focused the utility of highly disturbed patchy ecosystems for butterfly conservation.

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### RICE FIELDS AND THEIR IMPORTANCE FOR THE CONSERVATION OF AQUATIC BIRDS.

Rice covers an important portion of the planet, constituting the main diet of over half the world's population. Its cultivation cycle imitates the natural hydrology of wetlands providing conservation opportunities. Mobile aquatic birds use the patchily distributed pulses of rice production characteristic of these agricultural landscapes. We studied aquatic birds in rice fields within the 27,000 ha agroindustrial complex "Sur the Jibaro," Sancti-Spiritus. Rice fields harbored a wide diversity of species: 61 were aquatic, 50 granivores and 46 mostly insectivores and piscivores. Rice fields were an important foraging habitat for North American wintering waterfowl and for 16 species that breed in adjacent coastal swamps. Seven species use paddies for both breeding and feeding, while 54 use them mostly for feeding. The Yaguasa (*Dendrocygna arborea*), an endangered species endemic of the Caribbean, uses rice heavily by feeding nocturnally in harvested and flooded fields. Although pesticides have been diagnosed world-wide as a major wildlife problem in rice cultivation, in Cuba a 50% reduction in pesticide use through the implementation of biological pest control have reduced this hazard. Research results are used in an Environmental Education Program implemented with university biology students in schools, zoological gardens, and Forest Guard Corps throughout the country.

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#### MONITORING FOR GENETIC INTROGRESSION INTO AN ISLAND POPULATION: THE RED WOLF AS A CASE STUDY.

Reintroduced red wolves (*Canis rufus*) in Northeastern NC have been hybridizing with recently established coyotes (*Canis latrans*). Molecular genetic methods are being used to aid in the USFWS' goal to preserve the red wolf gene pool. The largest problem faced by field personnel is distinguishing morphologically between red wolves and hybrids. Genotypes were obtained at 15 microsatellite loci from the 14 red wolf founders to determine alleles present in the modern population. We combined this data with wild red wolf breeding data and microsatellite allele frequency data from SE coyotes to develop an assignment test based approach to identify unknown individuals. The second largest management problem is effectively screening vast areas of the recovery zone for red wolves, coyotes and hybrids. We addressed this problem using non-invasive genetic sampling of fecal samples and GIS technology. We created a species level diagnostic test using both restriction enzyme analyses on the cytochrome b region of mtDNA and sequencing of the control region of mtDNA. Over 400 scats were collected across 250,000 acres and 72% were successfully assigned to species. These techniques will help implement the adaptive management plan and play a key role in efforts to recover the red wolf.

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#### CONSERVEONLINE: AN ONLINE RESOURCE FOR THE CONSERVATION COMMUNITY.

The Nature Conservancy, in partnership with the Society for Conservation Biology, the Association for Biodiversity Information, and Community of Science, has launched ConserveOnline, a website designed to create a knowledge base for conservation and to foster information sharing and collaboration among conservation practitioners and researchers. The goals of the site are to provide conservationists and land managers at conservation organizations and government agencies with the practical tools they need to advance biodiversity conservation, and to link academic researchers with field practitioners. The foundation of ConserveOnline is an indexed, searchable library of conservation tools, techniques, data, and experience. We welcome broad participation and invite anyone with relevant documents, data, slide presentations, spreadsheets, software, images, or maps to add their material to the library. ConserveOnline also features Discussion Groups and Listservs, information about Conservancy and SCB programs, and links to other sources of conservation-related information.

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#### MOVEMENT PATTERNS AND POPULATION TRENDS OF AXIS DEER (AXIS AXIS AXIS) ON THE KALAUPAPA PENINSULA, MOLOKA'I.

The population of axis deer (*Axis axis axis*) on Kalaupapa peninsula increased for more than ten years following the removal of cattle in 1985. The overabundant deer population reduced the cover of Hawaiian vegetation, including naupaka, pohina and ilima, and converted grasslands to dense shrublands dominated by *Lantana camara* (lantana) and *Schinus terebenthifolius* (christmas berry). The deer population has declined by 77% since 1998 due mainly to starvation resulting from low availability of palatable species and hunting pressure. Three of twenty (15%) deer

survived eighteen months after being radio-collared in 1999. Several critical areas have been fenced to exclude browsing pressure. Documentation of axis deer movement patterns may help guide fence placement and eradication efforts. Daily movement patterns were determined by tracking radio-collared deer during day and night sessions. Deer moved to higher elevation, dense stands of *Psidium guajava* (guava) and christmas berry during the day and receded toward lower elevation, open grasslands at night. However, one deer migrated over 12 miles where it was shot outside the peninsula and another moved <1 km in dense christmas berry between day and night tracking sessions. This reclusive behavior will complicate eradication efforts on the Kalaupapa peninsula.

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#### THE ROLE OF ECOLOGY, ECONOMICS AND SOCIETY IN MARINE CONSERVATION: A CASE STUDY FROM THE CHANNEL ISLANDS.

Numerous marine species are becoming scarce due to a variety of factors, including increased levels of pollution, commercial and recreational fishing, management failure, and environmental fluctuations. Marine reserves have the potential to compensate for failed management and the impacts of fishing by increasing abundance, size, and reproductive output of fished species. In southern California, a group of state and federal agencies, commercial and recreational fishermen, environmentalists, and other community members worked together for two years to establish marine reserves for conservation and fisheries management in the Channel Islands National Marine Sanctuary. An advisory panel of marine scientists used a variety of innovative theoretical and empirical approaches to develop a recommendation for reserve size and location to meet the goals for conservation and fisheries management. A panel of economists and social scientists collected and evaluated data on commercial and recreational fishing effort and catch in the Sanctuary. The agencies, organizations, and individual stakeholders used the ecological recommendations and socioeconomic data to design a network of marine reserve areas for conservation and fisheries management. The Channel Islands marine reserves process provides a model for developing marine conservation policy using ecological and economic principles through cooperation and education of community.

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#### VIABILITY OF CALIFORNIA LEAST TERN METAPOPOPULATION AND EFFECTIVENESS OF MANAGEMENT ACTIONS.

The California least tern is federally listed as an endangered species. Its nesting habitat has been degraded, and many colony sites are vulnerable to predation and human disturbance. Most management efforts have concentrated on predation, an important source of reduced fecundity. We developed a metapopulation model of the California least tern. We defined each cluster of nearby colonies as a population. Within each population, the model included age-structure, year-to-year changes in survival and fecundity, regional “catastrophes” (strong ENSO events), and local catastrophes (reproductive failure due to predation). We simulated the effect of management by increasing fecundity at each population. The model predicted a continuing population increase and a low risk of a substantial decline in the next 50 years. However, this result was sensitive to the assumption about the vital rates. Under the assumption of low vital rates (pessimistic scenario), the model predicted a high risk of decline, although a low risk of extinction. The model results indicated that the effectiveness of management actions depend not only on their local efficiency (increase in fecundity due to protection at each population), but also on the number and spatial distribution of the populations selected for management.

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#### PALEOECOLOGY, BIODIVERSITY, AND HUMAN IMPACT: OSTRACODS AS INDICATORS IN LAKE TANGANYIKA, EAST AFRICA.

The ostracod fauna of Lake Tanganyika is exceptionally diverse, with approximately two hundred species and high levels of endemism. Ostracods valves are preserved in sediment cores in sufficient abundance to allow high-resolution paleoecological reconstruction of biodiversity turnover through the recent period of intensive land-use change in the lake’s watersheds. Ostracods serve as conservative indicators of change in benthic communities, because they have a higher response threshold to sediment inundation than fish and molluscs. Using fossil ostracod assemblages,

radiocarbon dating, and detrended correspondence analyses (DCA), we compared recent ostracod diversity trends in sediment cores offshore from two adjacent watersheds in northern Tanzania – one almost completely deforested, the other protected as part of Gombe Stream National Park. In the upper part of the cores from the deforested site, sedimentation rates tripled, and DCA plots and ostracod species abundance profiles revealed marked turnover in the dominant ostracod taxa through time. In contrast, no such changes were observed in the cores from the protected site. The paleoecological record of microinvertebrate diversity at these two sites suggests a recent, anthropogenic transition in the species composition of the benthic community offshore from the deforested watershed.

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**SELECTION CRITERIA FOR MARINE PROTECTED AREAS IN THE GULF OF THE FARALLONES, CA, USA.**  
Marine protected areas (MPA) comprise many forms, ranging from complete to limited restrictions on activities. Scientists and resource managers are closely examining the criteria for MPA designation. In the Gulf of the Farallones, California, several potential sites for marine protected area designation were identified based on simple criteria including ecological, sociological and regulatory components. Ecological criteria included elements such as species rarity and diversity, and source population significance. Sociological criteria took into account elements such as commercial and sport fishing effort. Regulatory criteria took into account jurisdiction, existing designations, and enforcement capabilities. Applying GIS models, we identified MPAs using simple boolean logic with the above criteria. Point Reyes Headland, for example, ranked high for all criteria. Ecologically, the site is significant, exemplifying one of the few locations in the world where major coastal upwelling occurs, and having great diversity and abundance of marine species. Fishing effort is limited because of remoteness and hazardous conditions. Finally, Point Reyes Headland comes under the jurisdiction of several agencies. These simple GIS models, using basic criteria, allow managers to promptly identify MPAs without extensive, long-term research to justify designation.

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**THE POPULATION GENETICS OF INVASIVE SPECIES.**  
Genetic and evolutionary processes may be key features in determining whether invasive species establish and spread. Invasive species may evolve both during their initial establishment and during subsequent range expansion, especially in response to selection pressures generated by the novel environment. The rate of change in response to natural selection is proportional to the amount of genetic variation present. If genetic changes and thus evolution during and after colonization are characteristic of invasive species, it will be important to understand the role of genetic diversity during this process. For example, one common feature of invasions is a lag time between initial colonization and the onset of rapid population growth and range expansion. This lag time is often interpreted as an ecological phenomenon (the lag phase in an exponential growth curve). However, lag times are expected if evolutionary change is an important part of the colonization process. This could include the evolution of adaptations to the new habitat, the evolution of invasive life history characteristics, or recovering from the effects of inbreeding associated with the founding event. Population genetic considerations also may be important to effectively control and manage invasive species.

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**CREATING A CONSTRUCTIVE RELATIONSHIP BETWEEN LOCAL COMMUNITIES AND MANAGEMENT OF CHATTHIN WILDLIFE SANCTUARY, MYANMAR.**  
Effective management of a protected area depends on a constructive working relationship between management and residents living around the area. As one of the first steps in building this relationship, we conducted surveys in each of 33 villages surrounding Chatthin Wildlife Sanctuary (CWS), a 103 sq mi. (168 sq km) protected area in central Burma which has one of the few remaining remnants of indaing forest, and is the last stronghold of an endangered species of deer, the thamin (*Cervus eldi thamin*). The survey was designed to serve as an easy and effective tool to begin communication between management and local communities. The purpose of the survey was to provide baseline data on people's perceptions of CWS in order to inform management strategies. For example, along the southern boundary, crop damage by thamin is a problem for local residents; while along the eastern boundary, lack of access to CWS for the extraction of resources is a problem. We present an analysis of the results and discuss implications for management of CWS.

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## GEOGRAPHIC PATTERNS OF RICHNESS AND ENDEMICITY IN ISLAND FAUNAS.

A worldwide survey of major oceanic islands and island groups was conducted to document patterns of faunal distribution and diversity and to put the Hawaiian Islands into a global perspective. In general, the faunas of oceanic islands differ from continental faunas in at least four significant ways. They are generally impoverished, disharmonic, and have a high percentage of endemic species. Island faunas are also thought to be unsaturated, although this is a matter of some debate. Beyond these four differences, there are a number of ecological and evolutionary trends that further distinguish island faunas from their mainland counterparts. Island species tend to have noticeably larger or smaller body sizes than do their closely related continental relatives. There is also a tendency for groups that can fly, such as birds and insects, to become flightless on islands. And as well there is a trend, most pronounced on isolated islands and archipelagos such as Hawai'i, for initial colonizing species to undergo adaptive radiation. Although islands comprise only about 3% of the earth's surface and in general support smaller faunas than do similarly sized mainland areas, because of the high incidence of endemism on islands they harbor a large fraction of the earth's fauna.

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### A HABITAT GAP ANALYSIS OF THE GALÁPAGOS ISLANDS.

Although the Galápagos islands are probably most famous for Darwin's finches, land iguanas, and giant tortoises, the archipelago is also notable for numerous endemic trees, shrubs, herbaceous plants, and invertebrates, many of which are restricted to single islands. The sizable Galápagos National Park covers more than 95% of the islands, providing protection for many of these unique species. A habitat gap analysis, however, shows that the majority of the highland habitats do not receive the same level of protection as do the arid zones that make up the majority of the archipelago. These moist highland environments are among the island's richest habitats for archipelago and island endemics, particularly for plants. A comprehensive plan to protect the biodiversity of the Galápagos needs to consider adequate protection and restoration of these highland communities.

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### A SPATIAL POPULATION SIMULATION MODEL OF A NON-NATIVE SEAGRASS.

Native seagrasses provide essential habitat for many estuarine species. Invasion by an exotic seagrass species with a different morphology may alter the habitat's community structure and thus is an important conservation concern. *Zostera japonica* (Zosteraceae) is a non-native eelgrass in Pacific Northwest estuaries. To help determine whether this seagrass is detrimental to native estuarine communities, we incorporate a non-linear patch expansion rate into a spatially explicit simulation model. Using field data, we parameterize the model with bathymetry data and size-specific patch expansion rates. We test the effects of competition for space between *Z. japonica* and native burrowing shrimp and the effects of "bad years", in which climatic and river flow conditions adversely affect *Z. japonica* survival. Results suggest that *Z. japonica* will spread, but patch centers are mobile and experience some dieback. The expansion ability of *Z. japonica* appears especially sensitive to shrimp population dynamics. We conclude that where abundant, burrowing shrimp will likely keep *Z. japonica* populations in check. In mudflats where burrowing shrimp or organisms with similar functions are not present, *Z. japonica* may be able to create monocultures across the habitat.

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### MODELING THE SPREAD OF AN INVASIVE PLANT IN NATIVE FORESTS OF HAWAII.

Organisms that appear benign in their home environments may become noxious invaders when introduced to new habitats, particularly on islands. *Tibouchina herbacea* (Melastomataceae) is a South American plant that has grown from its introduction to the Hawaiian Islands in the 1970s to dense stands in open habitats. Sparser populations are also present in the wet forests of the islands of Hawai'i and Maui. We use a spatially explicit, stochastic computer simulation to determine how quickly *T. herbacea* will be able to spread in a closed forest habitat. We parameterize the model using field data on seed set, seed dispersal, seed germination, seedling survival, and vegetative reproduction. We find that *T. herbacea* is likely to become a major pest in the closed forest of Hawai'i within the next few decades. Because the slowest spread occurs under conditions of maximal canopy cover and maximal aggregation of any small gaps within the canopy, we predict that disturbance to canopy cover is likely to increase the threat of *T. herbacea* spread, particularly if the disturbance is distributed throughout the forest. We explore the implications of this result for targeting particular life-history stages of *T. herbacea* in developing management strategies to control its spread.

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APPLICATION OF THE NESTED CLADISTIC ANALYSIS METHOD TO THE DISAPPEARING FROG SPECIES, *RANA BLAIRI*.

Frogs and other amphibians are disappearing from their historically occupied ranges at an alarming rate. Even widespread and abundant frogs, such as species in the *Rana pipiens* complex, are being affected in at least parts of their ranges. Information about population structure and historical biogeography of species of ranid frogs will be extremely useful for understanding how populations of *Rana* species will be affected by the spread of pathogens and other factors that may be causing extinction. We are surveying mitochondrial DNA variation in the species *Rana blairi*, which is undergoing rapid extinction in the southern part of its range (probably due to chytrid fungus infection). Templeton and colleagues have developed a new algorithm, the nested cladistic analysis, that uses molecular sequence data to differentiate several models of population structure from each other and from several historical phenomena. We will apply nested cladistic analysis to mtDNA allele phylogenies estimated from samples from forty populations of *R. blairi*. We will estimate levels of ongoing gene flow using appropriate models, as well as historically associated genetic subdivisions.

ALVAREZ, L. MARIA. Columbia University MC 5557, 2960 Broadway, New York, New York 10027-6902, USA. ILLICIT CROPS AND BIRDS OF COLOMBIA.

The forests of Colombia, even in protected areas, are being fragmented for economic exploitation and development including the cultivation of illicit crops: coca, and poppy. Over the last five years illicit crops in Colombia have grown an average of 21% per year, and may account for half the total area deforested in 1998. I present the first geographic analysis of the distribution of illicit crops in relation to areas of conservation priority for threatened and endemic birds. The most important sites affected by illicit crops are the southern Andes, the northern West Andes and adjacent lowlands, the Santa Marta, Perijá, and San Lucas mountains. The largest forested areas threatened by illicit crops are in Amazonia and the Amazonian East Andes, sites of relatively low conservation priority. Given trends in the expansion of illicit crops, and the narrow endemism of some bird species, the conversion of forests for illicit-crop cultivation may result in several extirpations. Hence conservationists should give high priority to the effective protection against illicit crops of existing and proposed forest reserves and parks. The conservation of threatened and endemic birds in Colombian forests may hinge on successfully curbing incentives for deforestation, including international trade in illicit drugs.

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AN INTEGRATED APPROACH TO THE CONSERVATION OF CARRIBEAN PARROTS IN THE GENUS *AMAZONA*.

Amazon parrots in the Caribbean are threatened by both general factors that impact other psittacines as well as specific factors characteristic of this region. Specifically, severe habitat loss and fragmentation, and continued illegal harvest have impacted these high profile birds. These threats are compounded in a number of species by unusual life history traits coupled with the enormous monetary value placed on them by collectors. Consequently, these circumstances give added priority to *ex situ* management for this group compared with many other related taxa. Presented here is an integrated approach employing techniques in molecular ecology for *in situ* studies, conservation genetics for *ex situ* management, molecular forensics for limiting trade, and strategic linkages with governments and NGOs as a model for conservation of these endangered island endemics.

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MAMMAL TAXONOMY AS A FURTHER THREAT TO ISLANDS BIODIVERSITY

As early as 10,000 years ago, humans have played an often unrecognized role in dispersing many mammal species in islands around the world. Early taxonomists described those isolated and sometimes morphologically distinctive mammals as 'species' and 'subspecies' which are often included in national and international Red Lists. If the origin of such 'taxa' is not taken into account in conservation inventories, the risks are: 1) to direct funding opportunities towards populations of artificial origin and of negligible evolutionary importance 2) to overlook the conservation value and status of true 'palaeoendemic' mammalian taxa 3) to inadvertently protect one of the historic causes of biodiversity loss on islands. In the Mediterranean islands almost all mammal species went extinct following human arrival and new species were introduced. The only palaeoendemic surviving mammals are two shrews of the genus

*Crocidura* which represent the true mammal conservation priorities in the region, often obscured by the greater interest for more appealing and erroneously believed 'typical' Mediterranean species. As we find similar cases in other parts of the world (i.e., *Procyon* species considered 'endemic' of the Bahamas and Lesser Antilles) we suggest that mammalian nominal taxa of proven artificial origin should be listed separately in conservation lists.

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#### EFFECTS OF SIMULATED LOGGING ON A THREATENED FERN IN CENTRAL OREGON.

The diminutive, xeric -adapted fern *Botrychium pumicola* (Oregon Moonwort) is endemic to pumice substrates in central Oregon. Initially found only at high elevations in the Cascade Mountains, this unique pteridophyte has more recently been discovered at lower elevations within commercial stands of lodgepole pine, putting its conservation into potential conflict with timber harvest activities. Our study (now in its third year) investigates some of the effects of timber harvest on *B. pumicola*, with the goal of providing information to Forest Service land managers for the development of conservation plans for this fern. Individual plants at seven study sites on the Deschutes and Winema National Forests were subjected to one of six treatments selected to simulate potential effects of logging and roadbuilding (burial, compaction, scraping, clipping, shading, as well as untreated controls), and subsequently monitored for emergence, growth and reproduction throughout the following growing seasons. Data from the first two years after treatment indicate that burying dormant plants with soil is detrimental to emergence, while scraping and compaction have negative effects the first year, with the potential for recovery in subsequent years. Clipping and shading had positive effects on growth and emergence, at least in the first year after treatment.

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#### SCIENTIFIC STANDARDS FOR ASSESSING SPECIES VIABILITY UNDER THE NATIONAL FOREST MANAGEMENT ACT.

The regulations implementing the National Forest Management Act (NFMA) direct the National Forests to provide habitat that will support viable populations of native and desired non-native vertebrate species well-distributed across National Forest lands. A proposed revision of these regulations would extend this requirement to other plant and animal species. The Forest Service has used a range of approaches to assess species viability, from individual expert opinion to detailed habitat and demographic modeling. Many Forest Plans have been challenged on either the adequacy of the management guidelines for species, or the adequacy of the process used to demonstrate that viability requirements have been met. At the request of the U.S.D.A. Forest Service, NCEAS convened a national panel of 14 scientists to review methods used to assess species viability on National Forests and make recommendations for standards and scientifically defensible but practical methods for evaluating species viability. I discuss the panel's findings and recommendation, as well as potential strategies for implementation.

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#### COYOTE CANYON LANDFILL: NATIVE VEGETATION RESTORATION RESULTS IN HABITAT CREATION FOR A THREATENED SPECIES.

The Coyote Canyon Landfill was identified as an area for habitat restoration in the Central/Coastal Natural Community Conservation Plan (NCCP) for Orange County, California. Coastal sage scrub vegetation was seeded on 104 acres of the Coyote Canyon landfill in 1994 as part of the mitigation program for the San Joaquin Hills Toll Road. The mitigation project required initial coordination to develop specifications for the landfill closure plan to accommodate planting the coastal sage scrub community. Avian surveys of the restoration site demonstrated colonization by the federally listed California gnatcatcher (*Polioptila californica californica*) showing an annual two-fold increase over the site as the vegetation developed. Nest monitoring and banding studies documented the breeding pairs of gnatcatchers from one pair in 1996 to three in 1997, seven in 1998, and fifteen in 1999. Overall, gnatcatcher breeding success was relatively high on the landfill. Low nest failure rates, perhaps due to limited predator populations on the landfill, appear to be responsible for the high nesting success. The Coyote Canyon revegetation site shows promise as a future source population site for the California gnatcatcher, thus fulfilling a policy of the NCCP governing habitat restoration to establish a defined historic ecosystem.

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## PROACTIVE ALIEN PLANT MANAGEMENT PROTECTS HAWAIIĪ PARKS: PARTNERS BATTLE INVASIONS ACROSS PARK BOUNDARIES.

HawaiĪ parks are making major progress in stemming the tide of alien plant invasions threatening Hawaiian ecosystems by fielding an expert weed control team that identifies and eliminates weed threats on a multi-island basis. The National Park Service Pacific Islands Exotic Plant Management Team (PIEPMT) travels between six parks controlling incipient invasions to prevent spread into the national parks. The PIEPMT utilizes the local knowledge of existing crews and integrated weed management techniques, to monitor and battle alien plant invasions in the parks or preferentially before they impact the parks. PIEPMT efforts are a core component of a multi-agency and private industry effort to control the establishment and spread of invasive species in HawaiĪ in the form of Island Invasive Species Committees (ISCs). Currently there are three ISCs working to prevent and control invasions on Maui Nui, HawaiĪ and OĪahu.

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## COMPLEX EVOLUTIONARY HISTORY IN THE BROWN TROUT: INSIGHTS ON THE RECOGNITION OF CONSERVATION UNITS.

Sixteen populations of brown trout *Salmo trutta* L. across 8 Portuguese river basins were screened for variation at 5 diagnostic loci (mtDNA and allozymes). Results revealed low to non-existent levels of introgression from hatchery reared fish of allochthonous origin. Population structure based on mtDNA revealed a mosaic pattern driven by past fragmentation and restricted gene flow with little correspondence to major river drainages or recently proposed OCUs on the Iberian Peninsula. Such patterns of variation offer a challenge to conservation strategies which base themselves on defining units of conservation, particularly if such units intend to reflect an hierarchical evolutionary structure. We suggest that geographically mosaic patterns of evolutionary lineages, as well as adaptively significant traits are common characteristics of many freshwater fishes. Thus, large-scale units, even if diagnosed by mtDNA clades, are often too heterogeneous to consider a "unit" for conservation. Alternatively, a bottom-up perspective which prioritizes unique populations is both more practical and more efficient in recognizing and preserving evolutionary diversity.

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## EDGE IMPACT ON TREE COMPOSITION IN REMNANT ANDEAN FOREST FRAGMENTS (COLOMBIA): LANDSCAPE AND PATCH LEVEL.

The harsh contrast between forest and pasturelands, creates an imbalance in abiotic conditions at edges when compared to the relatively stable forest interior, affecting tree composition. At five sites, abiotic variables, vegetation structure and tree composition (3 size classes), were recorded from the edge towards the forest (50m) every five meters. Decreases in temperature and increases in humidity (air and soil), were found from the edge towards the forest interior. Understory foliage density was higher at the edges, while overstory foliage was higher in forest interior. Richness and densities of trees among the sites differed in their responses to edges. Direct gradient analyses at the landscape level (all sites) did not show a response of tree composition as a function of distance, but there was a significant relationship with the abiotic environment. At the patch level (by site), tree composition responded to the edges (threshold 20-35m), but a significant relationship was not found with the abiotic environment, although it increased with size class increase. This suggests that generalizations of edge-effects at the landscape level are difficult to make due to site variations. At the patch level, tree composition responded differently to abiotic and biotic edge-effects depending on size class.

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## TWO PARADIGMS FOR UNDERSTANDING BROAD-SCALE EXTINCTION PROCESSES.

In 1994, Graeme Caughley noted that two distinct paradigms had emerged for understanding (and preventing) extinctions of single populations: the small population paradigm and the declining population paradigm. He argued that conservation biology would proceed most effectively if this dichotomy were broken down. Over the last decade the main focus in conservation biology literature has not been on single populations, but on broad-scale extinction processes affecting multiple populations. Examination of this literature shows that two paradigms have also emerged at this broader spatial scale: the "metapopulation paradigm" and the "habitat paradigm". The metapopulation paradigm assumes that suitable patches may be occupied or unoccupied, and that occupancy is strongly affected by

stochastic extinction and recolonization processes. The habitat paradigm assumes that distributions are determined solely by habitat quality. Predictive models can be rapidly developed using either paradigm. However, the predictions may be misleading because metapopulation variables (size and isolation) may be confounded with key habitat variables, which may not be easily measured. Management recommendations therefore depend on the paradigm adopted, the metapopulation paradigm emphasizing translocations and corridors, and the habitat paradigm emphasizing restoration. I argue that effectively synthesizing these paradigms requires research on local dynamics of multiple populations.

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CAN POPULATION GENETICS FILL AN ECOLOGICAL VACUUM?

The Giant Amazon River turtle, *Podocnemis expansa*, is found in rivers throughout northern South America. In large part due to its' colonial nesting behaviour, this endangered species has been heavily exploited in the past. In response to this situation, the Brazilian government created the National Centre for the Amazonian Chelonia, CENAQUA, to co-ordinate conservation efforts. One of the difficulties CENAQUA faces is that only limited information is available on many aspects of the natural history of this species, including migration ranges, nest-site fidelity, and levels of paternity. A collaborative study of the genetic diversity and structuring of populations across the greater Amazon basin was thus undertaken. This information will be used to improve the existing conservation management plan by 1) identifying unique genetic lineages and important new areas for protection, 2) testing the assumptions of colonial nesting behaviour, 3) providing genetic markers for monitoring breeding programs, and 4) evaluating the possible genetic basis of observed morphological/behavioural differences among populations. Preliminary evidence suggests a surprisingly low level of mitochondrial DNA diversity, although significant geographic structuring among haplotypes does exist. Future efforts will include analysis with nuclear markers and a comparison of these results with simulation studies.

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SARIGAN: HEINOUS TO HOPEFUL: VEGETATION RECOVERY AFTER FERAL ANIMAL REMOVAL ON AN UNINHABITED ISLAND IN THE NORTHERN MARIANA ISLANDS.

Sarigan is a 500 ha uninhabited island in the Northern Mariana archipelago which has been populated by feral pigs and goats for approximately 50 years. Sarigan supports several native wildlife species including the endangered Micronesian megapode (*Megapodius laperouse*) whose habitat was severely degraded. In 1998 feral pigs and goats were eradicated from the island. Permanent vegetation plots were established and initially surveyed prior to eradication of feral animals. The objective was to measure floral recovery as feral animal habitat degradation was mitigated. Since eradication the number of plant species in permanent plots has doubled, the canopy and ground cover has increased and in 2000 there was a significant increase in the number of seedlings present in the plots. There has also been an increase in the invasive vine, *Operculina ventricosa*. Most forest edges and seedlings in open fields are covered with dense mats of this vine. It remains to be seen if this weedy vine will be a limiting factor to forest recovery.

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LOWLAND FOREST LOSS AND PREHISTORY IN HAWAI'I: ARE HUMANS TO BLAME?

Pollen data from four wetland pollen cores from different lowland areas of O'ahu are compiled to document lowland vegetation prior to the island's colonization by humans. Such wetland cores provide one of the few direct sources of information on the nature of the pristine (pre-human) late Holocene vegetation of Hawai'i. The advent of prehistoric Polynesians is clearly evident in these cores with the appearance of charcoal particles, taxa indicative of landscape disturbance, introduced taxa, and the decline of forest taxa. The rapidity and extensiveness of forest loss with the advent of humans suggest that direct impacts as a result of human activities such as burning and gardening was minimal and do not account for the observed vegetation transformation. Several different lines of circumstantial evidence point to the introduced Polynesian rat, *Rattus exulans*, as a significant factor in the ecological collapse of the lowland forests. The implications of paleoenvironmental findings for conservation biology in Hawai'i are apparent, including the provision of baseline information on the nature Hawai'i's pre-human lowland vegetation communities,

the significance of certain species in these communities that are now extremely rare, and the probable importance of excluding rats for propagating native taxa in areas undergoing habitat restoration.

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#### THE ROLE OF INTRODUCED PATHOGENS AND VECTORS ON THE DEMISE OF AN ENDEMIC AVIFAUNA: LESSONS FROM THE HAWAIIAN ISLANDS.

The Hawaiian Islands are home to a critically endangered avifauna that is often cited as one of the most outstanding examples of adaptive radiation and speciation in the world. The introduction of mosquitoes (*Culex quinquefasciatus*) and both avian pox (*Poxvirus avium*) and malaria (*Plasmodium relictum*) to the islands has had an enormous impact on native forest bird communities and is believed to be one of the primary factors responsible for their collapse at lower elevations. We have documented the impacts of these diseases through studies of their distribution, pathogenicity, vector ecology, and epidemiology. Native Hawaiian honeycreepers are extremely susceptible to malaria with mortalities in some species as high as 90% following exposure to a single infective mosquito bite. Epidemic outbreaks are seasonal, dependent on vector populations, and may be driven by environmental factors, host immunity, and/or cycling of new parasite strains in the host population. Restoration of Hawaiian forest bird communities will depend on aggressive and creative management strategies that incorporate detailed knowledge about the dynamics of this disease system across large landscapes.

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#### INSULAR ISLAND EFFECTS ON THE ALDABRAN GIANT TORTOISE (*GEOCHELONE GIGANTIA*) POPULATION.

By 1900, tortoises were extirpated from all Indian Ocean islands, except Aldabra Atoll, where "a few" survived. By 1973-74, Aldabra's population recovered to 129,000 individuals. This 1997 revised estimate was based on the first Aldabran tortoise census in 1973-74, which used a 5% (292 ha) stratified random sample of Aldabra's land area. A 1997 replicate census using a 55.5% random sample (162 ha) of the 1973-74 plots revealed a decline ( $p < 0.001$ ) to 100,000 individuals (Bourn et al. 1999). Evidence are: 1) declines ( $p < 0.001$ ) in censused live tortoises from a) 1997 plots compared to 1973-74 plots and b) long-term monitoring transects; and 2) an increase in tortoise mortality ( $p < 0.001$ ). Aldabra's largest island maintains the highest tortoise density yet smallest-sized individuals; however, its subpopulation declined by 33%-41% ( $p < 0.001$ ). Low-density subpopulations increased by 60%-93% ( $p = 0.0001$ ) on Aldabra's middle-sized islands and maintain the largest individuals, yet represent <5% of Aldabra's population. Insular effects on density-dependent processes of a fragmented island population are attributed. These population changes present island colonization and evolutionary implications. Change directions and rates are associated with pressures on individual island's carrying capacities. Decreased forage productivity and accessibility and tortoise reproduction and growth constraints exacerbated these effects.

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#### DECISION ANALYSIS IN FISHERIES STOCK ASSESSMENT: WESTERN ATLANTIC BLUEFIN TUNA

Western Atlantic Bluefin tuna (*Thunnus thynnus thynnus*) are subject to commercial and recreational fisheries, under the management of the International Commission for the Conservation of Atlantic Tuna (ICCAT). The population is depleted to less than 20% of historic levels, and the current harvest quota may not allow the population to rebuild. ICCAT's stock assessments of bluefin tuna have been controversial in the past, in part because of uncertainty about the relationship between spawning stock size and recruitment of juvenile fish into the fishery. Furthermore, the management actions needed to rebuild the population to its maximum sustainable yield level depend strongly on the assumptions that are made about the stock recruitment relationship (SRR). At the 2000 bluefin tuna assessment, we presented a Bayesian method to estimate the probabilities of various functional forms of an SRR given a time series of stock and recruitment data. Without using a Bayesian method, the assessment was restructured so that the uncertainty

in the SRR was addressed, thus improving the credibility and usefulness of the assessment. We also discuss the role conservation biologists can play in improving the scientific basis of fisheries stock assessment and management.

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#### CURRENT STATUS OF MOUNTAIN YELLOW-LEGGED FROGS (*RANA MUSCOSA*) IN SOUTHERN CALIFORNIA.

Populations of mountain yellow-legged frogs (*Rana muscosa*) continue to decline in well-protected areas in southern California. Monitoring of known populations and presence/absence surveys were conducted in the Angeles National Forest (ANF) and the San Bernardino National Forest (SBNF) in the summer and fall of 2000. Most techniques and locations were a continuation of work by others that extend back to 1993. Currently, there are less than three known remaining populations in the SBNF and less than six known populations in the ANF. During our surveys, reproductive success was detected from only two of these sites. Similar declines are being reported from the Sierra Nevada populations of this species, although the habitat requirements of the frogs there appear much different. No chytrid fungus or iridoviruses were detected during any survey. Introduced trout appear to be the primary threat and removal experiments at some locations should begin immediately in order to restore historic habitat. Human recreational activities, including hiking, fishing, and bathing appear to negatively impact mountain yellow-legged frog populations. Continued monitoring of known populations, in addition to further searches of historical localities, is imperative for developing a conservation strategy for this very endangered species.

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#### PALM COMMUNITY RESPONSES TO EDGE INDUCED ENVIRONMENTAL VARIATION IN FOREST FRAGMENTS IN ECUADOR.

Edge effects on palm communities were evaluated in two 40-50 years old forest fragments. In each forest fragment three edges were examined through 9 10x20m plots placed at 0 (edge), 50 (middle), 100 (interior) m from the forest/no-forest border. All the individuals of 12 palm species were recorded and identified to species level. The environmental variables measured related with forest structure (number of trees 30 cm dbh, forest-phase), understory light, and undergrowth cover type were influenced by the edge closeness. Results show that the palm diversity and abundance are strongly influenced by the edge closeness. Edge plots have the lowest diversity levels of adult palms, while interior plots present the highest diversity. Palm tree density consistently diminished or disappeared from the edge plots. Understory palms may persist along forest edges if the forest structure is maintained. Low palm recruitment along edges show that the 'core area' is not expanding. Edge effects for the palm community penetrates at least 100 m into the forest fragments.

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#### EFFECT OF AN INVASIVE SPECIES ON THE POPULATION DYNAMICS OF A NATIVE BUTTERFLY (*PIERIS NAPI*).

Invasive species can disrupt co-evolved relationships in many ways. We are studying the effects of an invasive exotic weed on the population dynamics of a native butterfly. The invasive species, *Thalaspia arvense* spreads rapidly by invading disturbed areas and fulfills the same role as its native relatives in the life cycle of the butterfly *Pieris napi*, by acting as a larval host, but with one difference. Early instar larvae that feed on *T. arvense* die. We have collected field data on distribution of native and exotic host plants, habitat use and movement of the butterfly species, and the proportion of eggs laid on the exotic versus native hosts. Our previous work has shown that there is variation in oviposition preference of *P. napi* between native hosts and *T. arvense* which is heritable in a sex linked manner and depends on the length of exposure to plant species. We have used this information to construct a spatially explicit population model simulating the effects of the distribution of the invasive species on the population dynamics of *P. napi*. This model is of value to other systems where invasives are a threat or other factors are reducing a species' habitat quality.

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#### POPULATION DYNAMICS AND STATUS OF THE ENDANGERED HAWAIIAN MONK SEAL.

Hawaiian monk seal counts have declined by 60% since the late 1950s and current abundance is estimated at 1300-1400 seals. Counts declined about 5% yr<sup>-1</sup> during 1985-1993, and subsequently remained stable through 1999. Population trends are influenced by the highly variable dynamics of the six main reproductive subpopulations in the Northwest Hawaiian Islands (NWHI). Overall pup production has increased in recent years, but juvenile mortality also increased in varying degrees at several subpopulations. The largest subpopulation is at French Frigate Shoals, where counts of non-pups have dropped by 60% since 1989, and the age distribution has become severely inverted due to high juvenile mortality. Laysan and Lisianski subpopulations have remained low but relatively stable. In contrast, the population at Pearl and Hermes Reef has increased 6-7% yr<sup>-1</sup> since the mid-1970s. Similarly, the population at Kure Atoll has consistently grown since the mid-1980s, after several management actions. Finally, the small population at Midway Atoll, which was nearly extinct, is showing signs of recovery due largely to immigration from Pearl and Hermes Reef and Kure Atoll. Future abundance trends for the entire species will likely depend upon whether predicted losses at French Frigate Shoals are countered by gains at other sites.

BALDWIN, ROBERT F., and Aram J.K. Calhoun. Deering Hall, University of Maine, Orono, Maine 04469, USA. EFFECTIVE SCIENCE COMMUNICATION: A MAINE RESPONSE TO *CONSERVATION BIOLOGY IN PRACTICE*.

The goal of *Conservation Biology in Practice* is to "fill the gap between academic and practicing conservation biologists... to put conservation science into practice and conservation practice into science." We evaluated the effectiveness of *CBiP* by asking 72 Maine environmental professionals (from state and federal government, non-profits, schools, and private industry) to review the first issue and respond to a survey. A subset (7) will be interviewed during a focus group discussion. Preliminary survey results (12) indicate approval for the new journal, and that it will be a useful tool. Several respondents not already SCB members indicated they would subscribe to *CBiP*. Although all survey respondents have marked "conserving biological diversity" as of primary importance to their work, even those with graduate degrees in science have rated conducting scientific research as less important to their work. Focus group discussion will focus on broader issues of how science is best presented to the public. will present full results, including survey responses and excerpts from focus group discussion.

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EVALUATING GENETIC MANAGEMENT STRATEGIES IN CAPTIVE BREEDING PROGRAMS USING VORTEX.

Genetic management strategies for captive populations have evolved over the last 20 years from simply avoiding inbreeding to the currently recommended strategy of minimizing kinship. This means that kinship strategy provides a theoretically robust and simple way to identify the genetically most valuable animals to breed to maintain gene diversity. Four factors are considered when selecting pairs for breeding: the pair's average mean kinship, the difference in the pair's mean kinship, the inbreeding coefficient of potential offspring, and the extent of uncertainty in the pair's ancestry. Optimal pairs are those with minimum values for all criteria. However, few pairs are optimal for all criteria and little is understood about the trade-offs in prioritizing one criterion over another. For example, how important is it to select pairs with similar mean kinship values and what are the cost in terms of long-term maintenance of genetic diversity if this criterion is relaxed? Furthermore, alternative breeding strategies have been recommended. The kinship value strategy weights mean kinship values by reproductive values to take into consideration an individual's expected future reproductive performance. A modified version of the VORTEX population modeling program is used to assess the relative performance of different strategies for managing breeding programs.

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CONSERVATION CONFLICTS ACROSS AFRICA.

Recent studies have provided disturbing evidence that areas of outstanding conservation importance may coincide with dense human settlement or impact. We test the generality of these findings using 1°-resolution data for sub-Saharan

Africa. We find that human population density is positively correlated with species richness of birds, mammals, snakes and amphibians. This association holds for widespread, narrowly endemic and threatened species, and looks set to persist in the face of foreseeable population growth. Our results contradict earlier expectations of low conflict based on the idea that species richness decreases and human impact increases with primary productivity. We find that across Africa, both variables instead exhibit unimodal relationships with productivity. Finally, new prioritisation algorithms show that resulting conservation conflicts are not easily avoided at this scale, because many densely inhabited grid cells contain species found nowhere else.

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#### HAWAIIAN BIRD RECOVERY: REMOVING INVASIVE THREATS, RESTORING HABITAT, AND REESTABLISHING POPULATIONS.

Recovering palila (*Loxioides bailleui*) and their dry forest habitat requires managing a broad assortment of invasive species. Palila are threatened by predators and food competitors, and their habitat is threatened by alien species that browse native vegetation and disturb the soil, increase fire fuel levels, and suppress forest regeneration. These and other factors have concentrated the majority of palila in only 30 km<sup>2</sup> of subalpine habitat on western Mauna Kea. This population may be responding slowly to habitat improvements resulting from the reduction of feral ungulates but is vulnerable to fire and other catastrophes; thus, viable populations must be reestablished elsewhere. Attempts to reintroduce palila to northern Mauna Kea by translocating wild birds from the western slope have not yet reestablished a resident population. However, some birds remain for over a year before returning home, encouraging us to continue developing this approach. Additionally, reforestation of downslope pastureland will increase the elevation gradient along which the availability of critical foods, including seeds and caterpillars, varies through the year. Recovery also must include protecting palila from feral cats and rats; preventing the spread of alien grasses, vines, and shrubs; controlling insect predators and parasites that impact food resources, and managing fire.

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#### IS CONSERVATION IN PROTECTED AREAS BASED ON AESTHETIC OR ECOLOGICAL CAPACITY? ELEPHANTS IN BOTSWANA.

Large populations of browsing elephants *Loxodonta africana* alter vegetation composition in riparian savanna woodlands in northern Botswana. During the dry season, elephant densities of 7-12/km<sup>2</sup> have been recorded along the Chobe and Linyanti Rivers. When natural processes are allowed to regulate populations, the increasing abundance of one species may reduce the relative abundance of other species. Before elephants reach an ecological carrying capacity in northern Botswana, vegetation changes may alter the aesthetic appearance of riparian woodlands and influence the abundance of other species, such as endemic Chobe bushbuck *Tragelaphus scriptus ornatus*. Chobe National Park and Moremi Game Reserve are often viewed as pristine wilderness areas. However, a review of historical events shows that in addition to changes in rainfall, surface water distribution, and browsing wildlife, human caused factors such as elephant hunting, livestock grazing, frequent fires, rinderpest, and logging influenced vegetation composition and appearance over the past 150 years. Management alternatives that simultaneously address natural regulation of ecosystem processes, preserving biodiversity, and aesthetic values may not be possible. Aesthetic values may influence conservation decisions; however, understanding factors responsible for ecological change over broad periods of time is critical for the long-term protection of conservation areas.

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#### THE EFFECTS OF TEMPORAL AND SPATIAL SCALES ON ECOLOGICAL RESTORATION MONITORING: A NORTHERN TE UREWERA, NEW ZEALAND, EXAMPLE.

The northern Te Urewera ecosystem restoration project is an ambitious management initiative restoring 50,000 hectares of forest in New Zealand's North Island. The project area includes the entire northern sector of one of the largest forest-fragments remaining in the North Island today, Te Urewera National Park. The restoration work is primarily oriented towards invasive mammalian pest control. The objective of this study was to determine the success of this initiative in achieving ecosystem recovery, through comparison of a core management region with non-treatment areas. However, defining an ultimate goal for such a restoration project is difficult, due to the absence of pristine mainland forests to provide a benchmark. Therefore outcome monitoring, for gauging success, focussed on

characteristics of community ecology. It was found that spatial and temporal scales in monitoring had a dramatic influence on whether detectable differences can be identified. This is illustrated by results from: distance-sampling estimates of forest-bird densities; ground-transect collections showing differential predation and predator disturbance of fruit; canopy-surveys revealing differential fruiting and flowering; and seedling-plots. It is clear that spatial and temporal monitoring scales dictated by non-biological considerations can potentially lead to misleading or unclear information, and this has important implications for restoration management.

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NATURAL COMMUNITY CONSERVATION PLANNING ACT: UNIQUE APPROACH BUT IS IT WORKING?  
This study carries forward the exploration of whether or not the Natural Community Conservation Planning Act of 1991 is successful at preserving biodiversity while allowing development to occur in the Coastal Sage Scrub habitat. This study examines the amount and quality of habitat preserved, a population count of the three target species (California gnatcatcher, cactus wren, and orange-throated whip-tail lizard), and a count of the number of Coastal Sage Scrub species that have been listed on the state and/or federal endangered species list since 1991. A series of comprehensive interviews will also be conducted. The subjects include land developers, public officials, scientists, and environmentalists who have actively participated in the development and/or implementation of the NCCP throughout the five Southern Californian counties: Orange; San Diego; Riverside; San Bernardino; and, Los Angeles. This study will conclude if the Act is successful, if it has deficiencies, and whether or not this Act should be implemented throughout the United States.

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COMPARISON OF MACROINVERTEBRATE COMMUNITIES IN STREAMS OF THE LESSER ANTILLES.  
An ongoing survey of macroinvertebrates inhabiting the freshwater habitats islands composing the Lesser Antilles was initiated in September 1995. Islands sampled included Barbados, Tobago, Grenada, St. Lucia, Dominica, Montserrat, Nevis, St. Kitts, Saba, and Antigua. Qualitative collections were made by sweeping a dip net through the water column and by hand examination of rocks, plants, and debris submerged in both flowing and standing bodies of freshwater across the each island. In addition, water temperature was recorded at each site. Collections by previous investigators were also included. My collections have yielded over 250 species thus far, many of which are reported for the first time from these islands. Dominant taxa collected included several species of gastropods, decapod crustaceans, ephemeropterans, odonates, hemipterans, and coleopterans. Many of these taxa have fairly widespread distributions throughout the Lesser Antilles. Observations indicate that most stream species are associated with leaf packs and most pond species are associated with aquatic macrophytes. Generally the macroinvertebrate fauna of these islands is sparse, most likely due to the oceanic origins, small size, and human disturbance of freshwater environments of the islands.

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A RESEARCH PROGRAM FOR RANGELANDS OF THE INTERIOR COLUMBIA BASIN AND SNAKE RIVER PLATEAU  
The Interior Columbia Basin ecosystem (i.e., Columbia River, Klamath, Great, and Snake River Basins) encompasses portions of seven states and contains areas that possess some of the highest ecological integrity in the U.S. Here we report development of an integrative Plan to address priority research needs to support management of over 11 million ha of land administered by five Department of Interior agencies. In addition to reviewing assessments, contract reports, and EISs for the Basin, we have canvassed primary literature, agency and University researchers, and local resource managers to identify critical issues. Scientists and managers in 1999 agreed upon five research emphases: 1) restoration; 2) rangeland health; 3) aquatic-terrestrial interface; 4) development of monitoring and evaluation protocols; and 5) at-risk species and habitats. Issues include: exotic species; microbiotic soil crusts; fragmentation of shrub-steppe habitats; management in the face of anthropogenic disturbance, catastrophe, and uncertainty; restoring historic disturbance regimes (e.g., fire); riparian and wetland management; livestock grazing; multiple-scale monitoring; salmonids; and sagebrush-obligate species (e.g., sage grouse). The Plan supports a broad-scale approach to restore and maintain ecosystem health and ecological integrity through active, adaptive management of habitat and disturbance processes, framing local decisions within a consistent region-wide management direction.

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#### AVIFAUNAL COLLAPSE IN WEST AFRICAN FOREST FRAGMENTS.

West African tropical forests are the most-fragmented and least-studied in Africa. To determine how forest birds respond to 5 factors (patch size, patch isolation, canopy density, abundance of large trees, proximity to forest edge), we surveyed 61 species of forest birds on 121 transects in 35 forest fragments in Ghana's semi-deciduous forests. Twenty-two species of forest birds were area-sensitive (15 were never found in small patches), and 9 were edge-sensitive, but patch isolation and forest structure had little influence on which species occurred in forest patches. Species richness per transect increased with patch size over the entire range of patch sizes observed (3 to 33,000 ha). The total diversity of forest birds on 18 transects in 13 small patches (25 species) was comparable to the diversity on a single transect in a large forest patch (maximum 22 species). Clearly, only large forests will conserve many of these forest birds. Edge-sensitivity was not due to altered forest structure near patch edges. Species were unlikely to occur in patches smaller than ~4 home range areas. Diversity of forest birds did not vary with isolation (distance to large forest), suggesting that island biogeographic mechanisms had little influence on birds.

BELFIORE, NATALIA M., and Bernie May. Department of Animal Science, Meyer Hall, 1 Shields Ave. University of California, Davis, California, 95616, USA.

#### EFFECTS OF CONTAMINANTS ON THE GENOMES OF RED SWAMP CRAYFISH IN THE SACRAMENTO VALLEY OF CALIFORNIA.

We test whether population genetic patterns can be used by conservation biologists to understand effects of environmental stress, namely contaminants, on populations. Three mechanisms are hypothesized by which genetic shifts may occur. 1. Selection on resistant alleles can cause allele fixation at one or multiple loci, or reduction in genetic polymorphism. 2. Drift from population reductions or reduced reproductive success can cause genetic bottlenecks and reduced gene diversity. 3. Direct mutagenesis or the cumulative effects of repeated genotoxic damage can cause increased mutational load indicated by rare alleles. Genetic variation in red swamp crayfish is assessed at twelve microsatellite loci. Replicate populations exposed to multiple contaminants are compared to replicate reference populations. Stochastic processes are factored out to assess genetic patterns attributable to chronic contaminant exposure. All populations show significant population structure ( $F_{ST}$ ). Inbreeding coefficients ( $F_{IS}$ ) are higher in all contaminated populations than in reference populations. Samples from the most heavily exposed population show less than half the allelic diversity than those from the cleanest population. Genetic patterns, therefore, conform to the predictions of selection or bottleneck processes, and correlate with degree of exposure. Multiple biomarker assessments are used as supportive evidence to associate genetic patterns with contaminant exposure.

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#### THE IMPORTANCE OF EDGE HABITAT FOR ALIEN AND INDIGENOUS BIRD SPECIES IN NEW ZEALAND'S INDIGENOUS FOREST FRAGMENTS.

Indigenous forest fragments are often all that remains of New Zealand's indigenous biodiversity in the extensive agricultural matrix of the lowlands. Biodiversity planning issues for these forest remnants include understanding changes in bird abundance with forest remnant size and habitat quality, and the minimum size of forest remnant necessary to sustain indigenous bird species. This study sampled forest vegetation and bird abundance in isolated indigenous forest patches in across 2000 square kilometres of the Rodney District, north of Auckland. It revealed a decline in alien bird densities away from forest edges and an increase in indigenous bird densities towards the interior of forest patches. The change in bird densities reflected changes in forest vegetation composition between the edge and interior of forest habitat islands. With increasing patch size the density of alien bird species decreased and the density of indigenous bird species increased. The edge effect explained some of these changes in bird density. Minimum patch sizes were established during the breeding season for four indigenous and three exotic bird species. This study may provide some answers for planners trying to identify how and where to protect and restore landscape elements to maintain functioning lowland forests.

BENDER, DAVID W. National Tropical Botanical Garden, Limahuli Garden, PO Box 808, Hanalei, HI, 96714, USA. LOWLAND FOREST RESTORATION IN HAWAII: INVESTIGATING STRATEGIES FOR SEVERELY DEGRADED AREAS.

Restoring severely degraded lowland forests in Hawai'i is recognized as one of the greatest challenges to Hawaiian conservation biologists. The National Tropical Botanical Garden (NTBG) manages Limahuli Valley, consisting of 1,000 acres of tropical wet forest that provides habitat for at least 12 endangered plant species. The research presented is a result of a collaborative effort between the NTBG and U.S. Forest Service. The experiment investigates different combinations of treatments of existing alien vegetation, and the response of selected species as both out-plants and natural recruits. Experimental plots either had the over-story completely removed, the under-story sprayed with glyphosate, or both in combination. Plots in which the over-story was removed and under-story was killed with glyphosate responded with the greatest amount of natural native recruitment after 2 years, and resulted in site conditions best suited to continued management. Out-planted species were more vigorous and survival was higher in plots where over-story vegetation was removed compared with plots where over-story was retained. Our results suggest that restoration of highly degraded Hawaiian forests may be more feasible than previously thought, particularly in areas where removal of alien canopy and reduction of alien under-story can stimulate an existing native seed bank.

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#### DNA SEQUENCE VARIATION AND MORPHOMETRIC ANALYSIS OF TWO TYPES OF *KUHILIA SANDVICENSIS* IN HAWAII.

Aholehole, *Kuhlia sandvicensis*, are believed to be endemic to the Hawaiian Islands and are an important and popular food fish. Local observers have noted the presence of two "types" of *Kuhlia* in Hawai'i and have divided them into groups based on eye size. Currently, both morphotypes are identified as one species in the scientific literature. Because meristic counts in the two types of *Kuhlia* often overlap, a preliminary discriminant function analysis was conducted to determine if the specimens could be classified based on morphometric data. This analysis grouped the two types of *Kuhlia* with more than 95% correctness. Furthermore, a DNA sequence analysis (mitochondrial cytochrome b gene) revealed phylogenies with two monophyletic clades, which correspond to the aforementioned morphological types. Sequence divergences are high between the two morphotypes of *Kuhlia* and indicate species level differences. Due to their taxonomic classification as one species, management strategies currently in place are likely more beneficial for one species than the other. Thus, conservation and management strategies should be reconsidered, as these results indicate that the two *Kuhlia* morphotypes are genetically distinct populations. In addition, current research indicates differences in habitat preferences, and future research may elucidate variations in life history strategies as well.

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#### CONSERVATION STATUS OF MADAGASCAR'S RIVER ECOSYSTEMS: LESSONS FROM A LARGE ANCIENT ISLAND.

Madagascar is the fourth largest island in the world, comparable in size to Texas or France. It is also a continental fragment of Gondwana that has been isolated from other land masses for 90 million years. Large size and long isolation have resulted in great hydrographic complexity and a very high level of endemism and incidence of taxonomically basal taxa among the freshwater biota. Conservation of the river ecosystems of this large, ancient tropical island consequently faces fundamentally different challenges than those faced on small oceanic islands. Pressures on Madagascar's rivers operate overwhelmingly at large (catchment or supra-catchment) scales; deforestation and introduction of exotic species are the principal threats to these systems. These pressures have given rise to widespread ecological degradation (principally caused by sedimentation) and Madagascar now has the most endangered native fish assemblage in the world. Conservation of the island's river species and habitats faces two immediate challenges: the widespread and ongoing degradation already sustained; and the incomplete information available for making decisions and establishing priorities. Basic research, including biological surveys and taxonomic studies, combined with geographic information systems approach, is needed so that river systems can be more effectively considered in future conservation planning.

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#### TRADING NATIVES FOR ALIENS? FISH SPECIES BIODIVERSITY IN THE GREAT LAKES.

The Great Lakes are a model system for what is happening to fish species biodiversity throughout North America. The Great Lakes currently have 151 species, of which 17% (26) are established aliens. Fish stocking has been the single major source of aliens, accounting for 32%, and canals have been the next most important source (25%). There are multiple sources of aliens, but government sponsored stocking and aquatic transportation programs have made

principal contributions. The Great Lakes were once managed for natives, but after alien Pacific salmon were stocked to control the canal-entered alien alewife, government management plans shifted to preserving alewife and Pacific salmon for the sports fishing industry. Although the direct cause-and-effect are poorly known, four native species that were endemic to the Great Lakes are now globally extinct and an additional 11 native species are extirpated. However, at the species level, across the entire Great Lakes system, fish biodiversity experienced an overall increase of 11 species (26 established aliens minus 15 natives lost from the system). The Great Lakes is thus a larger-scale example of the famous Clear Lake, California situation cited in many conservation biology textbooks, showing a decline in natives and an increase in total species.

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#### RECOVERY THREATENED: NEW DECLINES IN PREVIOUSLY STABLE POPULATIONS OF DESERT TORTOISES.

The Goffs population of desert tortoises in the eastern Mojave Desert, Mojave National Preserve, California, has long been considered the Gold Standard of stable populations for the species. Populations have been monitored since 1977. Between 1980 and 1994, population densities for all sizes of tortoises remained between 140 and 173/sq. km; densities of adults ranged from 66 to 88/sq. km. No statistically significant differences occurred between sample years. Between 1994 and 2000 populations declined 80% for all sizes and 92% for adults; the changes were statistically significant. Results of hematological and plasma biochemical tests, ELISA tests for *Mycoplasma agassizii*, and cultures collected between 1990 and 1995 indicate increasing severity of shell disease (cutaneous dyskeratosis), increasing frequency of mycoplasmosis, and liver disease. Necropsies of three tortoises salvaged in 2000 implicate metabolic disease, shell disease, and elemental toxicosis. Other potential contributing factors are herpesvirus infections and droughts. This population decline follows similar catastrophic declines in eastern California in the Chemehuevi Valley in the 1990's and on the Chuckwalla Bench (1982-1996). Consideration should be given to disease-related causes of mortality in recovery efforts. California populations may require a Federal listing upgrade from threatened to endangered status.

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#### QUANTIFICATION OF THE EFFECT OF SUBSTRUCTURE ON EFFECTIVE POPULATION SIZE ESTIMATORS.

The effective population size ( $N_e$ ) is a key parameter in conservation biology because it determines the rate of inbreeding and genetic change. Unfortunately,  $N_e$  is difficult to estimate demographically in natural populations. Consequently, genetic  $N_e$  estimators are becoming widely used, along with powerful markers (microsatellites) and statistical methods. However, these estimators are based on models that include unrealistic assumptions such as the absence of substructure in the studied population. We quantified the loss in accuracy and precision due to substructure on the most commonly used genetic estimator of  $N_e$ , which is based on the rate of change in allele frequencies over time. We used an empirical approach by simulating data. We show that hidden substructure (and immigrants) can lead to a substantial loss in accuracy and precision as soon as 10–20 percent of the sample size is contributed by foreign individuals originating from another population differentiated by a  $F_{ST}$  of 0.1. Fortunately, such individuals should be detectable by clustering techniques or assignment tests. We quantified the effect of population differentiation ( $F_{ST}$ ) and of the number of loci used on the estimator. This work provides guidelines and some assurance to users of genetic  $N_e$  estimators when limited substructure or immigration exists.

BEYERS, JAN L., Therese O'Rourke, Tom White, and Sandiann Engh. USDA Forest Service, Pacific Southwest Research Station, Riverside, CA, USA (JLB) and USDA Forest Service, Cleveland National Forest, San Diego, CA, USA (TO, TW, SE).

#### MANAGING ENDANGERED SPECIES AND HUMAN USES IN HABITAT "ISLANDS": THE SOUTHERN CALIFORNIA NATIONAL FORESTS.

The four National Forests in southern California – the Los Padres, Angeles, San Bernardino, and Cleveland – comprise islands of relatively natural habitat in a sea of expanding human development. Demands on the Forests for recreation, transportation and utility corridors, water development, and other uses are increasing. The Forests are also home to 64 species listed or proposed under the Endangered Species Act. The four Forests recently completed joint consultation

with the US Fish and Wildlife Service over the effects of their current management plans on these species. To analyze the impacts of myriad uses on many species, a GIS database was set up to overlay Forest activities on known and potential species habitat. Spatial habitat models were developed with input from species experts. Another database was created to list and track interim conservation measures proposed by interdisciplinary specialist teams to protect habitat. Forest management teams approved a subset of the measures for the consultation package. The database tools – GIS layers and proposed conservation measures – will continued to be refined and used as the Forests begin a management plan revision process involving public collaboration. These tools may have utility for other organizations and are explained in this presentation.

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#### IMPACTS OF LAND USE CHANGES ON SOUTHERN CALIFORNIA BUTTERFLIES.

The landscape of southern California has changed dramatically over the last century. Many native habitats have been converted to other uses, thus changing habitat patterns in terms of fragmentation and isolation. The land use matrix surrounding habitats may contribute to changes in the flora and fauna within fragments. The short generation time of butterflies makes them well suited for an investigation of the effects of land use change and fragmentation. Researchers in England, the Netherlands, and Poland have observed morphological responses by butterflies to fragmentation. I measured museum specimens taken over the past 50 years at collection localities in southern California. I then looked at land use changes surrounding these habitat using a time series of aerial photographs. Differences seen have important implications for conservation planning. Individual habitat areas need to be evaluated not only in the context of their current isolation, but also the history of their surrounding land uses.

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#### THE EFFECTS OF ENVIRONMENTAL POLLUTANTS ON IMMUNOCOMPETENCE IN *PEROMYSCUS LEUCOPUS*.

To what degree habitat deterioration from pollution contributes to the long-term survival of natural populations is currently unknown. Laboratory models cannot reproduce environmental conditions experienced by natural populations, and may therefore not be sensitive enough to assess the effects of particular contaminants in the wild. The study of contaminants in natural situations has lagged far behind laboratory investigations of this subject, especially in terms of sublethal data, as well as the quantitative effects of pollutants on wild mammals at the population level. Previous work has documented the detrimental effects of exposure to high levels of heavy metals and polychlorinated biphenyls (PCBs) on laboratory mammalian immune fitness. To assess such effects in natural populations, wild white-footed mice, *Peromyscus leucopus*, were trapped from known polluted and pristine locations. Immunocompetence was evaluated via antibody and cytokine production as well as immunopathology. Initial results show no significant difference between clean *versus* contaminated sites. Uptake analysis, however, revealed low levels of tissue contaminants in mice. This may have failed to cause a threshold reduction in immunocompetence, as detected by the methods employed in this study.

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#### PATH OF THE PARROT: REGIONAL HABITAT LINKAGES AND CONSERVATION PLANNING IN TROPICAL LOWLAND FORESTS.

Little is known about regional resource gradients in lowland tropical forests or the animals that may rely on them. My case study demonstrates reliance of a large avian frugivore on a suite of lowland forest habitats arrayed in a specific spatiotemporal pattern, creating ecological interdependencies among habitats. For three years, I have documented that the adult population of Mealy Parrots breeding in northeastern Guatemala engages in predictable regional migrations within mature moist forests. Although the overall area covered by the parrots is considerable (10,000 km<sup>2</sup>), of greater significance is the consistency of their movements and specific locations they utilize. Even over distances of a few hundred kilometers there is variation in fruiting phenology, forest composition, and rainfall and these probably play a significant role in shaping the site-area requirements of the birds. Large protected areas, such as the 576 km<sup>2</sup> Tikal National Park and even the 21,000 km<sup>2</sup> Maya Biosphere Reserve, do not adequately protect the annual requirements of Mealy Parrots breeding there. My results illustrate the asymmetry of this landscape and underscore the importance of regional gradients and habitat connectivity in maintaining animal populations, and thus in conservation planning, in lowland tropical forests.

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#### ARE REINTRODUCTIONS OF RIVER OTTERS NECESSARY? PATTERNS OF GENE FLOW IN POPULATIONS WITHOUT BARRIERS.

Historically, river otters (*Lontra canadensis*) were present throughout most of North America but urbanization, pollution, and overharvest greatly reduced their distribution by the early 1900s. Recently, expensive projects have successfully reintroduced otters in many areas. We studied genetic diversity among populations of river otters inhabiting marine environments in wilderness areas of Prince William Sound, Alaska, to determine characteristics of sex-biased dispersal and gene flow in an environment without barriers to dispersal. With those data we constructed a model to evaluate the potential for natural repopulation under optimal conditions, *versus* the need for reintroduction in areas with geographic barriers to dispersal (i.e., inland habitats and terrestrial distance between watersheds). Fifty-five otters in three populations were radiotracked to determine patterns of dispersal, and genetic material (microsatellite DNA) was obtained from 110 individuals in seven populations to determine patterns of gene flow. Both telemetry and genetic data indicated that female otters generally showed site fidelity and males were more likely to disperse. Despite lack of geographic barriers in a marine system, dispersal distances were relatively short, indicating that the likelihood of natural repopulation from adjoining watersheds in inland habitats is limited when watersheds are distant.

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#### THE ECOLOGY OF A SUBSIDIZED PREDATOR: COMMON RAVEN.

Subsidized predators are species whose populations survive and often thrive on resources (e.g., food, water, safety, etc.) provided by humans. Common ravens (*Corvus corax*) are an excellent example of a subsidized predator. Their populations have grown precipitously in recent years as a result of the proliferation of human activities in the desert. In a multi-year survey, significantly more ravens were found at landfills and sewage ponds than at other human-dominated and natural areas. Radio-tagged ravens primarily moved between anthropogenic resource sites. Nestling and fledgling survivorship is higher in nests located near human-provided resources. Ravens prey on juvenile desert tortoises (*Gopherus agassizii*), a Federally-listed threatened species, over much of the tortoise's range. However, not all ravens prey on tortoises, and few appear to prey on them in large numbers. It is not known if raven predation is high enough to prevent tortoise recovery rangewide, but it is likely high enough in some areas to alter success of recovery efforts. Removal of selected ravens known to prey on tortoises will likely aid short-term recovery in some areas, but such efforts should be coupled with aggressive reductions in anthropogenic resources (e.g., garbage) made available to ravens.

BOERSMA, P.D. Department of Zoology, University of Washington, Box 351800, Seattle, WA 98195-1800, USA. MARINE RESERVES AND MARINE ZONING AS TOOLS FOR THE CONSERVATION OF MARINE MAMMALS AND SEABIRDS.

Ecological theory is an underlining construct in the design of terrestrial and marine reserves. The general theory for reserve design is widely accepted (i.e. bigger is better, importance of fragmentation, invasives, dispersal, and management). Although, most models of marine reserves were developed for mid-trophic level fish, marine conservation should also focus on top-predators such as marine mammals and seabirds. In the terrestrial realm, "wildlands" advocates have argued the only way to maintain top carnivores such as elephants, grizzly bears, or wolves is by designating large tracts of land as protected areas. This strategy however, does not fit the "commons" of the marine realm. The designation of small marine reserves, protected areas, and sanctuaries are unlikely to benefit long-term conservation of wide-ranging marine mammals or seabirds. For example Albatrosses breeding in the Southern Ocean Sanctuary are killed off the Brazilian coast. Effective conservation strategies require detailed life history knowledge. We need to better understand how different species use the environment and how uses change based on season, breeding location, and climatic variation. Because whales and seabirds use large and variable areas, large scale and flexible marine zoning may offer the most conservation benefits. This in turn necessitates international cooperation.

Bohorquez, Amy S., BARRY A. NICKEL, Emma K. Grigg, Deborah E. Green, Robin M. Bouse, Bruce E. Jaffe, Sarah G. Allen, and Hal Markowitz. San Francisco State University, Department of Biology, 1600 Holloway Avenue, HH222, San Francisco, CA 94132, USA (ASB, BAN, EKG, DEG, HM), National Park Service, Point Reyes National Seashore, USA (SGA), U.S. Geological Survey, 345 Middlefield Rd, MS 472, Menlo Park, CA 94025, USA (RB, BJ). THE HIGH PRICE OF GOLD: POSSIBLE EFFECTS OF HYDRAULIC MINING ON HARBOR SEALS IN SAN FRANCISCO.

The Gold Rush of the 1853 brought prosperity to California; however, the costs of the methods used to extract that gold are still being assessed today. The use of highly pressurized water washed over one billion tons of sediment from the Sierra Nevada foothills, a portion of which remains in the San Francisco Bay (SFB). The SFB also has the highest proportion of harbor seals with a red discoloration of their pelage. The red color results from iron oxide adherence to the keratin surface on the shaft of the coat hairs. This iron may adhere while seals are foraging in sediment contaminated by re-exposed hydraulic mining debris. In order to test this hypothesis, a model will be developed from a collaborative approach integrating behavioral, geological and chemical methods by, (1) synthesizing behavioral information obtained from VHF radio and satellite tagged harbor seals into a Geographic Information System (GIS); (2) classifying habitat from a digital terrain model based on bathymetric and hydraulic mining sediment data; and (3) chemically analyzing the red pelage for the hydraulic mining signature and other metals that may be linked to the debris. We present this plan to demonstrate the benefits of collaborative analysis for conservation issues.

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CURRENT STATUS OF RED-PELAGED HARBOR SEALS WITHIN THE SAN FRANCISCO BAY.

A previous study of the San Francisco Bay (SFB) red-pelaged harbor seals suggests a significant difference in haul out use by these seals at three sites within the bay. Allen et al. (1993) reported that red pelage resulted from iron oxide adherence to the keratin surface on the shaft of the hairs, likely related to foraging behavior. This coloration tends to make the red fur more brittle, leading to the loss vibrissae. Using several methods of comparison, a significant difference in the number of seals with red pelage was found between the central bay and the north and south bays. Continued analysis of this population from June 1999 to December 2000 showed significantly more of red-pelaged seals used the north and south bay haul out sites ( $p < 0.05$ ). We found red-pelaged mothers gave birth earlier in both pupping seasons ( $p < 0.05$ ). These results may indicate that red-pelaged mothers are older or foraging in nutrient rich areas, presenting a possible balance between foraging efficiency and the cost of the red-pelage. We recommend using this demographic data and the red-pelage as an indicator of optimal foraging areas and therefore identifying these areas for protection.

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MICROSATELLITE DNA PROFILING: MONITORING ATLANTIC SALMON (*SALMO SALAR* L.) FISHERIES IN NORTHERN IRELAND.

The Foyle Atlantic salmon Fisheries comprised of over 4000 km<sup>2</sup> catchments area and more than 3000km of main river systems, is one of the largest in the UK with catches of over 50,000 fish/year (estimated at 70-90% of all adult fish in the system). Recently a large EU funded project has been commissioned to supplement wild stocks within the system. Suitable management of mixed stock requires characterisation of the many individual components and their relative contribution to the fisheries. Little is known, however, on the genetic composition within the Foyle catchments. To address this situation, an extensive sample set of over 3000 fish, comprising of some 30 populations, was exhaustively collected from the major catchments areas of this region including temporal and spatial structure. Samples were screened for 7 highly polymorphic microsatellite loci. The combined result of the sampling strategy and extensive analysis of the microsatellite data, provided us with a unique data set investigating the effectiveness of DNA profiling in the management of this fishery, and also yielded an essential genetic baseline to monitor potential subsequent genetic changes that may occur due to anthropogenic effects (e.g. habitat alteration, stock supplementation).

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#### DECISION MAPPING FOR LANDSCAPE RESTORATION UNDER ADAPTIVE MANAGEMENT.

In conservation planning, collaboration is essential to creating landscape designs that are both ecologically and socially sustainable. On public lands, the process requires the balanced participation of communities, scientists, and managers, for each possesses unique and necessary stores of knowledge, experience, wisdom, and values critical to making sustainable decisions. In the Applegate Adaptive Management Area (Rogue River National Forest, Oregon, USA), a landscape design for the Little Applegate River watershed was completed. This community-based collaboration with natural resource management agencies resulted in a set of landscape issues and goals, as well as a watershed map of desired vegetation 200 years in the future. These mapped goals are now the basis for developing a 10-year conservation plan under NEPA using *decision mapping*, a process that integrates the values and knowledge of all stakeholders to improve the quality of decision making. "Value trees" and utility models were constructed to provide support for public involvement and analyses in the preparation of an environmental impact statement that delineates alternative restoration strategies for the watershed. Because they reveal areas of stakeholder differences, they were critical in resolving conflicts and assessing specific trade-offs among alternative strategies for landscape restoration.

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#### GENETIC DIVERSITY AND CONSERVATION.

A commonly accepted "conservation dogma" states that levels of genetic diversity provide a good indicator of extinction probabilities in natural populations. As a result, a considerable number of conservation genetic studies focuses on the detection of low levels of genetic diversity at the molecular level to suggest detrimental effects on fitness and, therefore, increases in extinction probabilities. This prevalent dogma assumes a simple relationship between genotypes and phenotypes and consistent detrimental effects on fitness through inbreeding depression. In addition, it disregards the potential effects of fine scale population structure, and mutation as an extinction factor. These issues have direct practical implications for conservation. For example, the relation between molecular and adaptive genetic variation has direct relevance on the preservation of phenotypic diversity and the characterization of conservation units. Inbreeding does not necessarily imply detrimental effects on population fitness, and fine scale population structure may be an important mechanism for maintaining genetic diversity in small populations. Finally, mutation may play a relevant role in extinction through the process of mutational meltdown. Experimental and field research in each of these areas is essential if we want to better understand the practical implications of genetic diversity in conservation.

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#### PRINCIPLES UNDERLYING THE USE OF MARINE PREDATORS TO DEFINE PROTECTED AREAS IN THE SOUTHERN OCEAN.

Land-based marine predators, including seals and seabirds, are particularly abundant in the Southern Ocean. A large proportion of these species use sub-antarctic islands for breeding and raising offspring. Based upon satellite tracking data collected from individuals of several species, it has been possible to define and examine variation in their foraging habitats. The spatial scale of such habitats varies extensively between species, ranging from 10s to 100s of kilometres from the breeding site for several penguin and seal species, to 1000s of kilometres for albatross species. Examination of these foraging ranges and, in particular, the detection of specific regions of importance to these predators may highlight areas of importance to both predators and their prey. In addition, the breeding performance of these predators can provide a measure of the status of the ecosystem, and in particular, changes in the relative biomass of krill. The integration of spatial information regarding foraging with temporal variation in overall breeding performance could be used as a tool for the identification of areas of recurring benefit to these species, and thus may allow us to define zones for protection in the pelagic environment.

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#### RE-VISITING THE CONTRACT: METHODS AND THEORY FOR INTEGRATING AMERICAN INDIAN AND EURO-AMERICAN APPROACHES TO CONSERVATION.

American Indian and Euro-American approaches to conservation are often perceived as incompatible because of significant contrasts in philosophy, practice, communication styles, and social organization. In collaboration with tribal and non-tribal scientists, we developed methods, analysis, and theory for integrating Indian and non-Indian approaches to conservation planning. We assert that meaningful engagement of American Indians and the adoption of Indian approaches to conservation must explicitly consider law, concepts, ethics, and ecology as an integral whole in the planning process. To this end, and to understand how Euro-American and Indian perspectives can complement each other, we employ *cognitive maps*. A standard method in cognitive and decision sciences, cognitive maps are visual tools that we employed to improve inter-cultural communication and understanding of the socio-ecological relationships of the two communities. Specifically, cognitive maps elucidated the delicate relationships between "values" and "facts" in both cultures. This format provided an equitable medium to examine both scientific viewpoints and helped unravel the tangle of cultural assumptions that block collaboration. Cognitive mapping revealed the multiple and shifting relationships of ecological phenomena and beliefs. We illustrate this process using specific examples of fire re-introduction as part of current federal and tribal restoration plans in the United States.

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#### RARE AND THREATENED LIVERWORTS: AN OVERLOOKED AREA OF CONSERVATION IN THE NEW ZEALAND BOTANICAL REGION.

New Zealand is an archipelago that is both geographically and climatically diverse. Recently, it has been stated that the decline in biological diversity is New Zealand's most pervasive environmental issue. The impact of potential pressures such as micro-habitat loss and fragmentation on the liverwort flora have not been previously investigated. This is alarming because it is estimated that New Zealand has c. 10% of the world's liverwort species, and more importantly, has 48 of the 73 liverwort families. Because of these factors together with the high level of endemism, the liverwort flora of New Zealand is considered to be of worldwide significance. First, this study identified potential threats to the New Zealand liverwort flora, and second, developed a preliminary checklist of threatened liverworts to be considered as candidates for the World Red List. Selection of species was based on field studies spanning three decades, extensive herbarium records, and bibliographic references. Case studies illustrating the different categories of threat occurring in New Zealand include examples from a monotypic family and a monotypic genus. We conclude that research relating to the conservation biology of the New Zealand hepatic flora requires great urgency and recommend areas of priority.

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#### NONINVASIVE POPULATION MONITORING OF NORTH AMERICAN RIVER OTTERS (*LONTRA CANADENSIS*) USING FECAL DNA.

Conservation and monitoring of North American river otters (*Lontra canadensis*) is challenging as they are a semi-aquatic, wide-ranging species, and typically occur at low population densities. Mark-recapture census methods are inadequate due to the difficulty of capturing individuals, and to the stress and potential injuries suffered by the otters. To date, noninvasive methods developed for monitoring river otter populations have been considered impractical for general use. We report here a pilot study of a noninvasive molecular method for monitoring *L. canadensis* populations. Fecal (scat) samples were collected during a survey of latrine sites from September through November 1999, at the Chopawamsic creek watershed on the US Marine Corps Base at Quantico, Virginia. Protocol was developed for extraction of otter DNA from scat using a soil DNA extraction kit. Extracted DNA was successfully amplified with mitochondrial 12S rRNA, microsatellite, and Y-chromosome primer sets in order to assign species, sex, and individual identity to otters based on their scat samples. From these data, sex ratio and minimum population size were determined. This study demonstrates the feasibility of population monitoring of *L. canadensis* using DNA from fecal samples, and should allow more precise population estimates in the future.

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#### BIODIVERSITY AND NONFUEL MINERAL DEVELOPMENT – COMPETITION OR COEXISTENCE?

As human populations continue to increase, we see a corresponding increase in the demand for consumptive uses of our natural resources. This in turn hastens loss of biodiversity by fragmenting habitat and disrupting ecological processes. Our traditional approach to development has been generally haphazard and driven by accessibility and opportunity rather than careful comprehensive planning. The Gap Analysis Program and the USGS Geologic Division investigate the feasibility of identifying which domestic mineral resource tracts could be explored with the least affect on biodiversity. Recognizing that exploration and development can have disruptive effects to biodiversity, either from the direct consequences of mining or from opportunistic growth by other sectors, it would be advantageous to integrate biological analyses early in the process of prioritizing mineral exploration. Geologists model “permissive” and “non-permissive” areas for potential mineral exploration as biologists model predicted distribution of species and vegetation alliances in the GAP Program. We use data from Montana to analyze mineral sites and GAP data. We spatially integrate the results to generate a ranking of sites indicating mineral potential and value for biological resources (richness and representation). We describe the feasibility of creating practical scenarios for future development of resources.

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#### RESERVE SIZE, HUMAN DEMOGRAPHY, AND WILDLIFE EXTINCTION IN WEST AFRICA.

Species-area models have become the primary tool used to predict baseline extinction rates for species in isolated habitats, and have influenced conservation and land use planning worldwide. In particular, species-area models are used to predict faunal relaxation as a result of natural demographic processes after habitat patches are reduced in size. However, where human influences such as hunting or the introduction of exotic species are common, extinction rates higher than those predicted by species-area models are expected and conservation plans based solely on species-area models may fail. Here, we show that extinction rates for 41 species of large mammals in six nature reserves in West Africa were 14 to 307 times higher than those predicted by reserve size under the species-area model. Ninety-eight percent of the observed variation in extinction rates among reserves was accounted for statistically by human population and reserve size. Extinction occurred at higher rates than predicted by species-area models for carnivores, primates and ungulates, and at the highest rates overall near reserve borders. Our results indicate that, where the harvest of wildlife is common, conservation plans should focus on increasing the size of reserves and reducing the rate of hunting.

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#### EFFECTS OF HABITAT ALTERATION ON COMMUNITY STRUCTURE IN HAWAIIAN STREAMS.

Streams throughout Hawai'i have been altered by water diversion, flow reduction, channel modification, introduced species, and water-quality degradation. As population increases and land-use changes, watersheds are becoming far different from those that once sustained native stream communities. During a 3-year study on Moloka'i, stream diversions were shown to correlate with reduced habitat availability and higher species overlap for fish and macrocrustaceans, potentially resulting in increased competition and predation. Dewatering can also inhibit downstream dispersal of larvae and upstream migration of post-larvae, critical to the life cycle of native amphidromous species. On O'ahu, the U.S. Geological Survey's National Water-Quality Assessment Program has shown urbanization, associated with channel modification and reduced canopy cover, to result in higher water temperatures and increased temperature fluctuations, habitat characteristics favoring non-native fish. Benthic invertebrate community composition also was influenced by habitat alteration; the ratio of Diptera to Trichoptera varied positively with siltation and negatively with velocity. Total invertebrate abundance was greatest at forested sites, while taxa richness (predominantly non-native species) was higher at degraded sites. As Hawai'i's population increases, the potential for watershed modification also increases. Understanding the relation between habitat alteration and aquatic community structure is critical for the development of sound management strategies.

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## VARIATION IN PESTICIDE TOLERANCE OF RANID TADPOLES AND PATTERNS OF AMPHIBIAN DECLINE.

There is significant variation among and within amphibian species with respect to reports of population decline; declining species are often found in environments that are physiographically similar to environments where the same species is thriving. Because variability exists among organisms in their sensitivity to environmental stressors, it is important to determine the degree of this variation when undertaking conservation efforts. We conducted both lethal (time-to-death) and sublethal (activity change) assays to determine the degree of variation in sensitivity of tadpoles to a pesticide, carbaryl, at three hierarchical levels: among ranid species, among several populations of a single ranid species (*Rana sphenocephala*), and within populations of *R. sphenocephala*. We observed significant variation in time-to-death among the nine ranid species, and among the 10 *R. sphenocephala* populations we tested. Four out of eight *R. sphenocephala* populations exhibited significantly different times-to-death among families. The magnitude of the activity change when exposed to sublethal carbaryl levels was significantly different among species and within *R. sphenocephala* populations. Chemical contamination, at lethal or sublethal levels, can alter natural regulatory processes (e.g., juvenile recruitment) in amphibian populations and should be considered as a contributing cause of declines in amphibian populations.

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## DAKOTA SKIPPER POPULATION GENETIC STRUCTURE IN A FRAGMENTED NATIVE PRAIRIE LANDSCAPE.

The Dakota skipper (Hesperiidae: *Hesperia dakotae*) is a lepidopteran native to central North American tallgrass and mixed-grass prairie. Agricultural conversion has resulted in the loss of approximately 98% of its native habitat in Iowa, Minnesota, North and South Dakota, and Manitoba, Canada. The species has been extirpated from Iowa and only remnant fragments of tall and mixed-grass prairie remain in government and private preserves. As a result, it has been considered for protection under the US Endangered Species Act and is listed as Threatened by the State of Minnesota and the Province of Manitoba. We used protein electrophoresis to assay genetic variability at nine sample locations throughout its current range. Twenty-one isozyme loci were assayed, 12 of which were polymorphic. Significant isolation by distance was detected among the seven Minnesota and South Dakota sites suggesting historic dispersal among these populations in continuous habitat. The two northwestern-most sites in Manitoba were similar in allele frequencies and showed significant genetic divergence from the other sample locations. These results suggest that preservation of the remaining genetic diversity of Dakota skipper populations will require preservation of habitat fragments from throughout its geographic range.

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## VOLUNTARY CONSERVATION OF SIGNIFICANT NATURAL RESOURCES ON PRIVATE LANDS: MAKING IT WORK.

The National Natural Landmarks (NNL) Program recently saw the end of a 10-year moratorium that had limited program activity and new designations. This long moratorium, enacted when property rights groups questioned the effects of NNL designation on private property, caused program coordinators to move into a more service oriented role to support the voluntary conservation efforts of landowners already participating in the program. Assistance to NNL owners and managers has ranged from grants to support research, monitoring, and education to “hands on” projects that have forged local partnerships and site improvements. All 587 designated NNLs are nationally significant for their biological or geological resources. They are widely dispersed around the United States and its territories. The National Park Service, through the NNL Program, provides an important link between these sites by serving as a conduit for information and by providing outreach through technical specialists located at parks. The results have been increased conservation and knowledge about these important areas, more efficient use of public funds through partnering, and improving conditions at some of the sites. Now that the program is fully functioning again, the NNL staff is poised to continue this level of support to existing and future participants.

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## HABITAT LOSS AND EXTINCTIONS IN THE HOTSPOTS.

Nearly half of the world's plant species and a third of terrestrial vertebrates are endemic to 25 ‘hotspots’ of biodiversity. None of these hotspots retains more than 30% of its pristine habitat. Due to this habitat loss, we expect many hotspot endemics to have become extinct or to be threatened with extinction. We use the IUCN Red Lists to test

this expectation. Overall, between a half and two-thirds of all threatened plants and 57% of all threatened terrestrial vertebrates are hotspot endemics. For birds and mammals predictions of extinction based on habitat loss generally match numbers of species independently judged extinct or threatened. For reptiles, amphibians, and plants, many less hotspot endemics are considered threatened or extinct than expected. However, this mismatch is small in temperate hotspots, suggesting that many endemic species in the poorly-known tropical hotspots have yet to be listed as threatened. Finally, we show that the Eastern Arc, Philippines and Pacific islands can least afford to lose any further habitat, and that if current deforestation rates continue the Caribbean, Tropical Andes, Philippines, Mesoamerica and Sundaland will lose the most species in the near future. Without urgent conservation intervention, we face mass extinctions in the hotspots.

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#### IS ISOLATION DECREASING OLD-GROWTH FOREST BIRD OCCURRENCE IN NORTHERN FINNISH RESERVES?

Old forest birds have been sharply decreasing in numbers during the last decades in Fennoscandia mainly due to the fragmentation associated with commercial forest harvesting. This decrease has been particularly evident in northern Finland where forestry has been very intensive, whereas adjacent areas in Russian Karelia have remained relatively untouched. Using a hierarchical approach, we ask how landscape characteristics of Northern Finnish forest reserves and their spatial location affect the occurrence of resident old forest birds. Proportion of old forest habitat had a clear positive effect on species number only in reserves further away from Russia. In areas close to Russia, with higher overall proportions of old-growth forest, proportion of habitat was negatively associated to species number. Reserve isolation was only marginally associated with species richness in areas close to Russia. Our results suggest that the effects of landscape structure on old-forest bird occurrence were not homogeneous across the reserve network, and that this variation might be related to thresholds in species responses to habitat availability and to the spatial location of the reserves within the network and in relation to source areas in Russia.

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DECREASED FITNESS AND SURVIVAL OF NATIVE AMPHIBIAN LARVAE IN A MARSH INVADDED BY AN EXOTIC PLANT SPECIES.

The worldwide decline of amphibian populations and the increase of exotic species are issues of concern in natural resource management and conservation. The presence of exotic vertebrates is known to contribute to amphibian declines, but little information is available on how exotic plant invasions affect amphibians. This study assesses the impact of purple loosestrife (*Lythrum salicaria*) on *Bufo americanus* tadpoles in northern New York. I monitored survival, developmental rate, and diet of *B. americanus* tadpoles in field enclosures in a marsh invaded by purple loosestrife and in a marsh dominated by native *Typha* spp. Tadpoles developing in the purple loosestrife marsh had significantly lower survival and slower developmental rates compared to those in the cattail marsh. Preliminary gut analyses suggest that the tadpoles in the cattail marsh consumed algae of higher nutritional value than tadpoles in the purple loosestrife marsh. Decreased fitness and survival of tadpoles in purple loosestrife may ultimately cause reductions in adult breeding populations. These results suggest that invasion of exotic plants may contribute to amphibian declines.

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#### IMPACTS OF FRAGMENTATION OF A COASTAL DUNE/MARSH COMPLEX ON TERRESTRIAL VERTEBRATES.

Coastal wetlands in California have been reduced by 95% and the remaining habitat is often highly disturbed and fragmented. The last remaining intact dune/marsh complex in California south of Point Dume is the Tijuana River National Estuarine Research Reserve. This reserve encompasses approximately 2,500 acres: 1,660 acres are upland consisting of marsh upland, coastal sage scrub and coastal dunes. Coastal dunes form the western border of the reserve, urban and military development and agriculture comprise the remaining boundaries with relict marine terrace mesas along the south. This island of habitat is at the mouth of the 1,735 square mile Tijuana watershed shared

between California and Mexico. Reptiles, amphibians and small mammals have been inventoried and monitored using passive pit-fall trapping and active searching since March 1997. 200 days of sampling at 15 points throughout the reserve has yielded over 4,250 captures across 3 species of amphibians, 17 species of reptiles, and 13 species of small mammals. The results indicate a decline and possible extirpation of several sensitive and protected species while other sensitive species remain common. Long term management of this unique ecosystem must balance the needs of both upland and wetland species in this fragmented landscape.

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#### CONSERVATION BIOLOGY REQUIRES LEARNING EXPERTISE RATHER THAN KNOWLEDGE ALONE.

I present ideas derived from contemporary cognitive psychology about how and what people learn, how those ideas modify educational goals for science and what they imply about adjustments in teaching methods. Study of the performance of experts in many fields led psychologists to a refined concept of 'expertise,' meaning the knowledgeable and flexible ability to address and resolve novel problems in a technical domain. This view of expertise seems a reasonable educational goal for conservation biology. Acquiring expertise turns out to require not knowledge alone, although it is essential, but intellectual traits and practices collectively called 'a self-regulated metacognitive perspective.' (Metacognitive refers to knowing management of one's thoughts, technical knowledge and intellectual abilities.). These attributes can, in turn, be learned through guided participation in a variety of goal-directed, problem-solving projects, which should include the means for students to plan and to reflect upon their own performance. My school's program has implemented a perspective on 'professional practice' to help students understand and set goals, teaches problem-solving directly and indirectly, and uses learning projects monitored with student portfolios to support self-regulated performance.

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PRAIRIE RESTORATION: AN INTRODUCTION TO BIOLOGICAL INQUIRY.

As a part of a major curricular reform, biology faculty members at Grinnell College have created a suite of new introductory courses, each of which explores a particular biological problem. *Prairie Restoration* introduces students to basic concepts in conservation biology, while emphasizing the ways that biologists ask questions, test hypotheses through observation and experimentation, and communicate their results. The course is taught in workshop format at our biological field station and local remnant prairies. It is structured in investigative blocks. Following two initial blocks that introduce students to methods of comparative and experimental analysis of prairie communities, teams of students carry out long-term investigations of their own design. Students publish the results of these projects in an electronic scientific journal ([www.grinnell.edu/cera/tillers.html](http://www.grinnell.edu/cera/tillers.html)). We also include discussions of the history of the prairie region, and the ethical and economic challenges to the conservation and restoration of grasslands. We are assessing whether this approach to teaching introductory biology succeeds with students whose learning styles conflict with traditional lecture formats. In our second year, 75% of the students reported that the course changed their perspective on science. A majority indicated higher confidence in their ability to learn about new scientific topics.

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#### ATLANTIC FOREST "ISLANDS" CLASSIFIED THROUGH BUTTERFLIES: AREA, HABITAT, AND POPULATION INSTABILITY.

The minimum size of a reserve for the preservation of options (species, communities, interactions) varies with the organisms and resources studied, habitat heterogeneity, disturbance, and isolation. The Brazilian Atlantic Forests (an ancient system of complex topography and high endemism) have a long history of natural and anthropic disturbance: over 90% are strongly fragmented, leaving thousands of forest "islands" with 10-100 ha. Green, humid, and pesticide-free vegetation, even though anthropic, gives potential connectivity between such fragments throughout much of the region. Butterfly communities have been inventoried and followed in many sectors for over 50 years, seeking to establish baselines for conservation monitoring, planning, and management. Area classes range from "intact communities" (usually > 10,000 ha, heterogeneous habitat) down through different degrees of instability (in 100-1000 ha fragments, over a third of the species present may be transient, showing strong population imbalances) to subminimal systems requiring intensive management (< 10 ha or very uniform, greatly depleted). Resident/migrant forest-interior butterflies including bait-attracted Nymphalidae, Ithomiinae, Riodininae, and Papilionidae are especially useful in classifying the local system. Many rare or threatened taxa on a 102-species list are recorded more rapidly and regularly in heterogeneous larger areas, and are useful for evaluation of system "integrity."

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#### ECOSYSTEM CONSERVATION IN MOHELI, COMOROS ISLANDS: A CO-MANAGEMENT APPROACH.

The Comoros Islands, a biodiversity hotspot in the West Indian Ocean, contain a high level of endemism. Political instability and limited funding, creating high potential for continued biodiversity loss, hamper existing efforts for biodiversity conservation. The history of international conservation and development projects in Comoros has been largely unsuccessful with few long-term results. The dire situation in Comoros warrants a new conservation approach: co-management, conservation from the bottom-up. Co-management, empowering local communities, offering alternative enforcement and a means of sustainable funding, is a viable solution. We conducted a year-long interdisciplinary evaluation of the co-management approach implemented by an inter-organizational project in Comoros. The Moheli Marine Park, a model for this new approach, offers tangible examples and insight applicable to similar situations. Though co-management is not immune to inter-village conflicts, weakness of government law enforcement, and political instability and unrest, with 80% of the responsibility in the hands of communities, the Moheli Marine Park has made notable strides. Methodical interdisciplinary examination of the strengths and shortcomings of the co-management approach reveal its versatility for application elsewhere and offer a template for effective scientific research and monitoring, policy-making, and management of protected areas in island nations.

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#### BIOLOGICAL IMPACTS OF HUMAN DISTURBANCE ON TWO HORNED LIZARD SPECIES (*PHRYNOSOMA*) IN SOUTHERN CALIFORNIA.

The dramatic urbanization of the southwest over the past century presents a potent threat to horned lizards (*PHRYNOSOMATIDAE: Phrynosoma*), as several aspects of their biology makes them particularly susceptible to the effects of human development and habitat disturbance. Since 1995, we have studied the foraging ecology and habitat use of San Diego coast horned lizards (*P. coronatum blainvillei*) occupying undisturbed and disturbed (by fire or grazing) coastal sage scrub habitats. We found Coast horned lizards were significantly smaller and lighter in the grazed habitat, while lizards from the undisturbed habitat had significantly richer and more diverse diets, smaller home ranges and moved shorter distances. In another study, we compared the eco-physiology of desert horned lizards (*P. platyrhinos*) occupying undisturbed Mojave desert habitat with lizards from an area used by the US Army for military training maneuvers. In contrast to the Coast horned lizard results, desert horned lizards were significantly heavier in the disturbed areas and had higher rates of food intake, but did not differ in home range size from lizards in the undisturbed habitat. Thus the ecological consequences of habitat disturbance for horned lizards likely depends on habitat type and species, and may occasionally be beneficial.

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#### AN INTEGRATED PROGRAM FOR PLANT CONSERVATION IN HAWAI'I.

The Hawaiian archipelago is one of the most isolated island chains in the world. The large diversity of habitats found here has resulted in the evolution of an extremely unique biota, exemplified by 90% endemism of the Hawaiian flora. However, following human contact, starting approximately 1,500 years ago, many of the Hawaiian ecosystems have been altered and more than 50% of the native flora has either gone extinct, is listed as endangered or threatened, or appears to be declining. Conservation of Hawaiian plant diversity requires the implementation of an integrated strategy of species recovery and ecosystem management that is well coordinated among the various agencies, organizations, and individuals. The U.S. Fish and Wildlife Service's Hawai'i and Pacific Plants Recovery Coordinating Committee is facilitating the development of a conservation strategy to help with the definition and implementation of conservation programs to stabilize and restore this unique flora. Major components of the strategy are: 1) initiate emergency actions to keep species from going extinct, 2) implement species and community maintenance and/or restoration efforts to recover the species and the habitats the native plants depend upon, and 3) conduct other activities, such as public education and outreach programs, in support of plant conservation.

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#### THE EFFECTIVENESS OF PARKS IN PROTECTING TROPICAL BIODIVERSITY

Over the past two decades, parks have been criticized as unable to protect the biological resources within their borders against growing human pressures, a claim which holds critical implications for conservation strategies. To test the hypothesis that parks are in fact an effective means to protect tropical biodiversity, we gathered and analyzed information on threats, impacts, local conditions and management activities from 93 protected areas in 22 countries. Analyses showed that these parks were largely successful at stopping land clearing, and to a lesser degree effective at mitigating logging, hunting, fire and grazing. Our most basic finding was therefore that tropical parks have been surprisingly effective in addressing major threats, often in a context of significant underfunding. Despite this success, a clear need exists to improve park effectiveness in some regards, perhaps especially against illegal hunting. The most effective parks were characterized by relatively strong basic management activities, such as enforcement, boundary demarcation, and direct compensation to communities. These findings suggest that creating new parks and increasing support for existing parks will both make a significant contribution to long-term biodiversity conservation in the tropics.

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#### WEEDS DATABASE - WHAT, WHERE, HOW, WHEN.

Dealing with weeds means dealing with all the planet's plants. By their nature, islands are vulnerable to weeds. Efficient weed control demands accessible information: What is the weed? Where is it? How to kill it? This lesson has been learned in New Zealand, a set of islands, with half its flora being exotic. The Department of Conservation (DOC) has developed a database to contain information to address these questions. Much of the important information existed but as scattered gems inaccessible to managers. After ONLY 6 months of activity it ALREADY contains more than 30,000 observations, 1700 species, 1000 images and 2600 control techniques. Information is retrieved by staff through the DOC intranet using web browsers. This is despite the geographical isolation of many DOC offices. The database is fully interactive. This means users from all over New Zealand can enter new information in any of the fields at any time. Staff are required to enter data, gained through surveillance, monitoring and weed control activities. Data are entered continually, and immediately available to all users, thus supporting DOC's innovative approach to weed management. Ultimately, the database will be made available through the world wide web.

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#### GENETIC AND FIELD STUDIES SUPPORT SPECIES STATUS FOR THE HIGHLY ENDANGERED OKARITO BROWN KIWI POPULATION IN NEW ZEALAND.

Several decades ago Brian Reid from the Department of Conservation recognized that Brown Kiwis from Okarito on the South Island of New Zealand had different vocalizations from other populations of Brown Kiwi. Subsequently, genetic studies revealed that Okarito birds were genetically closer to the North Island Brown Kiwi than to other South Island populations, and they were therefore classified within the Northern species (*Apteryx mantelli*). To further determine if the Okarito population should be considered as a distinct species from that of the North Island, we sequenced the control region and the Cytochrome b, ATPase 6 and ATPase 8 genes of mtDNA. Field studies were also conducted on the ecology, behaviour, morphology and parasites of Okarito and North Island Brown Kiwis. The sequence data demonstrate that the remnant Okarito population is genetically depauperate, and constitutes a distinctive phylogenetic lineage 9% divergent from other Brown Kiwi lineages. Field data provide additional support for the evolutionary divergence of the Okarito Brown Kiwi, and along with the genetic analyses warrant its recognition as a new species. With a total population of around 300 birds this species is highly endangered and must be accorded priority conservation status.

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#### PHYLOGENY AND INFERRED COLONIZATION PATTERN OF HAWAII'I'S ENDEMIC FLYCATCHER, THE ELEPAIO.

The five currently recognized subspecies of 'elepaio constitute a monotypic genus (*Chasiempis*) which is endemic to the Hawaiian archipelago. 'Elepaio from Kaua'i (*C. s. sclateri*), the geologically oldest of the major Hawaiian islands,

are often presumed to be the ancestors of the populations on the youngest island of Hawai'i (*C. s. sandwichensis*, *C. s. ridgwayi*, and *C. s. bryani*). However, whether the populations on the youngest island of Hawai'i were established by geographically intermediate O'ahu lineages, or whether they were the result of a colonization event that bypassed O'ahu is questionable since the three islands forming the Maui-Nui complex located between O'ahu and Hawai'i have neither fossil records nor contemporary populations of 'elepaio. Two mitochondrial regions totaling approximately 800 bp were sequenced and analyzed using three different methods of cladistic analysis. Phylogenetic estimations based on neighbor-joining, parsimony, and maximum-likelihood cladistics yield evidence of an interesting colonization pattern for this species. Since habitat loss does not sufficiently account for the rapid decline of the endangered O'ahu 'elepaio, understanding the founding of these populations and examining the genetic implications of how the O'ahu subspecies differs from its stable counterparts on Kaua'i and Hawai'i is an essential piece of the 'elepaio conservation puzzle.

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**THE RECOVERY PROGRAM FOR THE 'ALALA (*CORVUS HAWAIIENSIS*): PROGRESS AND CHALLENGES.** The 'alala (Hawaiian crow) is the only extant Hawaiian corvid. Abundant prior to 1900 on the island of Hawai'i, it is now critically endangered, with a population of 29 individuals. Suspected causes of decline include mammal predation, shooting, avian disease, and habitat modification and fragmentation from logging and agriculture. Recovery actions began in earnest in 1993 and were focused on the remaining wild flock in South Kona, on the western slope of Mauna Loa. Release of captive-reared juveniles sourced from wild nests was aimed at expanding the population in the wild. Retention of some juveniles in two captive breeding facilities enhanced the size and genetic diversity of the initially small captive flock. The 27 juveniles released over 5 years foraged well, but social integration with wild adults did not occur. Tracking of telemetered juveniles revealed unsuspected mortality factors: infection with novel pathogens and predation by the endangered 'io (*Buteo solitarius*). Released 'alal? suffered high mortality but did not breed despite reaching adult age. This first experimental phase was concluded in 1999. Through this recovery program, a viable captive flock has been created that will allow for future experimental releases in protected areas where habitat management has reduced mortality factors.

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**PROBLEMS WITH MINIMUM CONVEX POLYGONS: A CONTRIBUTION FROM THE NCEAS EXTINCTION RISK PROJECT.**

In many instances, presence data are the only kind of data available for the estimation of the geographic ranges occupied by species. Minimum convex polygons (convex hulls) are a standard tool for estimating species' ranges. They are used for making area statements and for assessing trends in occupied habitat, and the results contribute to the assessment of the conservation status of species. We show by simulation that estimates are very likely to be biased. The biases may be substantial and increase with sample size, the underlying shape of the species habitat, the magnitude of errors in locations, and unevenness in the spatial and temporal distribution of sampling effort. The errors affect both area statements and estimates of trends. Some of these errors may be reduced through the application of Delauney triangulation, randomisation tests and heuristic rules, but they cannot be eliminated entirely. Other methods for estimating the extent of species' ranges should be preferred.

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**CAN PALEOECOLOGY GUIDE RESTORATION? FINDING A LOST WORLD ON KAUA'I.**

Developments in paleoecological research and ecological restoration on Kaua'i offer an opportunity to explore the linkages between the two fields. Coring and excavations in the Maha'ulepu cave system highlight a remarkable fossil site preserving a well-dated stratigraphy of vertebrate bones, invertebrate shells, diatoms, pollen, plant macrofossils, ancient DNA, and human artifacts. Integrated site analysis documents the decline and extirpation, after human arrival, of endemic birds and snails and their replacement by a depauperate assemblage of cosmopolitan exotics, and shows that many plant species with highly restricted ranges today were formerly widespread. In combination with results from 11 other dated sites, this work provides evidence for island-wide transformation by human activities and biological invasions, resulting in perhaps three waves of extinction. These probably correlate with initial human arrival, prehistoric overpopulation, and European settlement. Benefits of this research to restoration include: 1) proposals for reintroduction of extirpated taxa that are extant elsewhere; 2) identification of challenges to restoration in the form of missing adaptive zones and trophic interactions; and, 3) recognition of integrated sites as resources for

scientific study and public education. Potential for closer collaboration between paleoecologists and restoration biologists is ultimately limited only by the availability of suitable sites.

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#### CONSERVATION GENETICS OF CAPE FEAR SHINER (*NOTROPIS MEKISTOCHOLAS*).

Cape Fear shiner, *Notropis mekistocholas*, is a small cyprinid fish endemic to the Cape Fear drainage of North Carolina, USA. This species was listed as endangered in 1987, and only five small populations have been documented. Current and potential threats to Cape Fear shiner include the existence of dams and hydroelectric plants, land use changes, and habitat deterioration. All known populations are presently separated by at least one impediment to inter-population movement. A genetic study of this species has been implemented to assess the presence of population structure, inbreeding, and recent changes in effective population size ( $N_e$ ). This information will be useful for future conservation efforts, which may include supplementation. A suite of 16 dinucleotide repeat microsatellite markers (nuclear-encoded) have been developed for Cape Fear shiner, and samples from three populations provided by the USFWS have been analysed. Assessment of variation in the mitochondrial genome by sequencing and single strand conformation polymorphism (SSCP) analysis has also been proposed.

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#### ARE LAND-COVER MAPS INCORRECT OR IS VEGETATION A POOR PREDICTOR OF BIRD DISTRIBUTION?

Bird species are selective on the vegetation types in which they are found but predictive models of bird distribution based on variables derived from land-use/land cover maps tend to have limited success. In this paper we test the hypothesis that the poor predictive power of some land-use/land-cover maps is partially due to the use of land-cover categories of little relevance to birds. In two areas of 4900 km<sup>2</sup> of Western Andalusia, Spain, we compared the predictive ability of models derived from the 1995 land-use/land-cover map of Andalusia from the Sinamba (Consejería de Medio Ambiente, Junta de Andalucía) and from a vegetation map built from satellite images for this study. We sampled the presence/absence of bird species at 1144 points using point-count surveys and measured vegetation structure at sample points. Statistical models for each species were built with Generalized Additive Models using as predictors land-cover variables derived from the two land-cover maps. We compared for each bird species the percentage of correct classification of the best model derived from each map. The results show that model predictions can be improved with land-use/land-cover maps built considering explicitly bird vegetation requirements.

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#### INTRODUCED PREDATOR REMOVAL: A TOOL FOR RESTORING THE ENDANGERED ALEUTIAN CANADA GOOSE.

The Aleutian Canada goose (*Branta canadensis leucopareia*) was nearly extinct by the 1930s largely due to predation by introduced arctic (*Alopex lagopus*) and red foxes (*Vulpes vulpes*) on their remote nesting islands in Alaska and Siberia. The nesting islands historically had no native mammalian predators. When foxes were introduced for fur production, they quickly extirpated geese and other species of native birds. Most of the historic nesting islands are now part of Alaska Maritime National Wildlife Refuge, and a project has been underway since 1949 to eradicate introduced foxes to restore native biological diversity. By 2000, foxes had been removed from 38 islands totaling more than 400,000 (ha), and Aleutian Canada geese had increased from less than 1,000 birds to more than 35,000. This increase, along with protective measures at wintering areas in California, justified removing the goose from the endangered species list. Other native birds, particularly seabirds and endemic taxa of terrestrial birds, also have increased 2 to 10 fold on islands where recovery has been studied.

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#### DESIGN OF RESERVE NETWORKS AND THE PERSISTENCE OF BIODIVERSITY.

Site-selection algorithms are used in reserve design to identify networks of sites that maximize biodiversity given some constraints (e.g. cost, total area, etc.). These algorithms are mostly based on a snapshot of species occurrence and they ignore the question of how well species persist in the selected sites. I will present a theoretical approach that considers spatiotemporal dynamics in order to assess the effectiveness of site-selection algorithms in terms of species

persistence. Once a set of sites is selected by a common algorithm, we apply a metapopulation model to simulate species occurrence through time. We look at the species extinctions at the selected sites in two situations: first, when all sites are included in the simulation, and second, when the non-selected-sites are excluded from the simulation (i.e. assumed to be destroyed if they do not become a reserve). The distinction is done to emphasize the importance of the non-selected sites for the spatial dynamics of the system. The results show that species persistence may be strongly dependent on patches not included in the selection. In summary, our results support the call for the integration of spatial population modelling in reserve network design.

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#### DRY FOREST RESTORATION IN HAWAII.

On the island of Hawai'i, remnant native dry forests are dominated by fountain grass (*Pennisetum setaceum*), a highly invasive exotic bunchgrass. To investigate cost-effective methods for re-establishing native plant populations in these areas, we established 8 experimental blocks in a highly degraded treeless area dominated by fountain grass. Each block consisted of 4 plots randomly assigned to 1 of 4 fountain grass control treatments: control, weed whack/herbicide, weed whack/black plastic mulch, and bulldoze. We also erected 50% shade cloth structures over 4 blocks to simulate light conditions found under intact native forests. We divided each plot into 4 quadrats: 1 outplant quadrat, 1 direct-seed quadrat, and 2 control quadrats. At the end of the experiment 2 years later, we found that the percent cover of native plants was greatest in the bulldozed plots, intermediate in the weed whack/herbicide and weed whack/plastic treatments, and least in the control plots. The percent cover of native species was also greater in the shaded vs. full sun plots, and greatest in the outplanted quadrats, intermediate in the seeded quadrats, and least in the control quadrats. These results suggest that relatively cheap and efficient techniques can be employed to restore Hawai'i's native dry forests.

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#### CONSERVING POOL-BREEDING AMPHIBIANS: BEST MANAGEMENT PRACTICES (BMPs) FOR TIMBER HARVESTING AND DEVELOPMENT NEAR VERNAL POOLS.

Vernal pools are poorly regulated because of their small size (typically less than ½ acre) and seasonal hydroperiod. The cumulative loss of small, isolated wetlands threatens populations of obligate pool-breeding amphibians and invertebrates as well as facultative wildlife. One of the most effective tools for conserving small, isolated wetlands is citizen conservation focused on responsible landuse practices. In the northeastern United States, Best Management Practices (BMPs) for timber harvesting near vernal pools have been extremely general and lack prescriptive guidelines. We have developed comprehensive voluntary BMPs for timber harvesting that provide specific management recommendations. These BMPs were developed with input from major stakeholders and reflect the best available science on breeding habitat and landscape needs of pool-breeding amphibians in our region. Three management zones are recommended: (1) the vernal pool depression, (2) the vernal pool protection zone (100 ft around the pool), and (3) the amphibian life zone (100 to 500 ft). For each zone, a description, management objective, rationale, and specific recommendations are provided. These BMPs are applicable to harvesting throughout the northeastern United States. BMPs for residential development, developed by scientists throughout the northeastern United States, reflect the needs of pool-breeding amphibians in fragmented, developing landscapes.

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#### HOW IMPORTANT IS OLD-GROWTH?: RESPONSES OF BREEDING BOREAL BIRD SPECIES TO FOREST AGE AND LOGGING DISTURBANCE.

Although successional stage preferences are relatively well documented in Ontario's boreal mixedwood forest breeding bird community, little is known about the sensitivity of this group to changes in stand age as a result of disturbance by fire or logging. We surveyed boreal forest bird communities using point counts in 18 post-harvest and 16 post-fire, closed-canopy mixedwood sites in northeastern Ontario that varied in stand age from 29-98 years. Differences in species habitat occupancy with respect to age and disturbance origin independently of age were compared using logistic regression models. Several canopy-foraging Parulid warblers and one cavity nesting resident, Red-breasted nuthatch (*Sitta canadensis*), showed threshold relationships with stand age, indicating potential

sensitivity to changes in stand age relative to other species. Few species showed significant effects of disturbance origin using stand age as covariate in the model. Our results highlight the importance of older boreal mixedwood stands in conserving habitats for bird species that are showing negative population trends elsewhere in North America.

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#### ARE THE FORESTS OF THE EASTERN PETÉN ANTHROPOGENIC?

In order to examine the relationship between patterns of human settlement during the Classic Maya Civilization (1,100 YBP) and the contemporary tropical forests of the Petén of eastern Belize, we conducted quantitative inventories of all woody stems > 1.5 cm. DBH on three forested sites: El Pilar, Terra Nova and Ix Chel. The sites have been abandoned since Classic times, and represent a gradient of Classic settlement densities (200, 50 and 2 structures km<sup>-2</sup>). All three sites had low species richness (94, 89 and 103 species, respectively, at asymptote on a species-area curve), and low beta diversity (Sorenson's index of similarity of between 0.58 - 0.71). Although the species richness of the three sites was independent of the density of structures, the total basal areas of the forests, as well as the percentage of vines (in terms of both individuals and species), were inverse functions of settlement density. An enumeration of the species of economic value to the Maya suggests that the oligarchies of these forests are the result of high grading over the past 4,000 years by the Maya. We therefore conclude that the forests of the eastern Petén are anthropogenic.

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#### FEDERAL REGULATORY ISSUES AFFECTING EXOTIC VERTEBRATE CONTROL IN INSULAR AREAS IN THE USA.

The intention of this presentation is to familiarize the audience with federal regulatory and registration issues that impact proposed exotic vertebrate species control efforts for conservation purposes in insular areas the United States. Several techniques that have been successfully used for vertebrate control (e.g., toxicant use patterns) for endangered species restoration in insular areas outside of the United States are not approved for use (or have limited approval) in this country. Federal, state, and non-governmental wildlife management agencies are investigating methods to gain regulatory approval for several conservation-oriented rodent control techniques using toxicants in insular areas in several sites in the United States. Multi-agency efforts in Hawai'i to develop chemical control techniques for introduced rats and *Eleutherodactylus* frogs will be used to illustrate federal regulatory issues. The use of specialized techniques to control vertebrate exotics in insular areas in the United States is realistic but will need to be conducted or developed in a manner that meets current federal regulations. Wildlife management agencies in the United States must realistically consider research costs to gain federal regulatory approval of novel control techniques.

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#### MANAGEMENT AND PREVENTION OF ALIEN REPTILES AND AMPHIBIANS: BROWN TREESNAKES AND CARIBBEAN TREE FROGS.

The introduction of alien terrestrial reptiles and amphibians to new localities worldwide has gained increasing public and scientific attention in recent years. Much of this attention has been focused on the establishment of the brown treesnake (*Boiga irregularis*) on the island of Guam and this introduced predator's subsequent ecological, economic, and societal impacts to the island. Concerns over the introduction of this pest snake to Hawai'i coupled with the recent introduction of a relatively conspicuous species of Caribbean tree frog (*Eleutherodactylus coqui*) continues to make the impacts of alien reptiles and amphibians an issue in this state. This is a realistic concern when one considers that the Hawaiian Island chain originally had no herps and currently has 30 species of established alien herps. The rate of alien reptile and amphibian species introductions to the state continues to increase at a steady rate while this pattern is stable for all other vertebrate taxa. We will review current issues associated with management and prevention of brown treesnakes and Caribbean tree frogs and discuss herp management issues in Hawai'i as they relate to the observed synergistic ecological relationship between the highly fecund smaller introduced herps and the brown treesnake on Guam.

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## FERAL GOATS IN THE GALÁPAGOS ISLANDS: PRESENT SITUATION, ERADICATION EFFORTS, AND THE FUTURE.

Feral goats (*Capra hircus*) are present on all five inhabited and one uninhabited island within the Galápagos Archipelago. Eradication has been successfully conducted on six uninhabited islands ranging in size from 12 to 12,996 ha. The effects of eradicating goats have been dramatic, with bare earth being converted to native forest in some cases. Pinta Island (5940 ha) is the most recent successful eradication, being declared goat free in 2000 after the removal of over 41,000 animals. Goat eradication is currently being conducted on uninhabited Santiago Island (58,465 ha) which has a large well-established population. Plans for eradication on Isabela Island (458,812 ha) are awaiting funds for implementation, which have currently been approved. Isabela's goat population is growing rapidly and continues to expand its range. The campaign on Isabela is expected to start in 2002, and last for 5 years, while Santiago is expected to be eradicated within 5 years. Eradication or low-level control are planned for the remaining four inhabited islands. Recent advances in the Judas goat technique, involving sterilization and increased estrus behavior, are expected to facilitate eradication success.

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## SCIENTISTS AS EDUCATORS: N.S.F. GRADUATE TEACHING FELLOWS IN K-12 EDUCATION AT THE UNIVERSITY OF MAINE.

In an increasingly human-dominated landscape, public understanding of environmental issues is especially important. Consequently, conservation biologists will have to play a more active role in explaining why biological concerns must be considered in decisions on how to use land and natural resources. Here we provide information on a National Science Foundation sponsored program at the University of Maine that helps to meet this need. The program underwrites fellowships for 12 students (ten graduates and two undergraduates) to demonstrate science in local K-12 classrooms. A major goal is to enhance science education of K-12 students by providing expertise, equipment, activities, and role models that would not otherwise be available to teachers and students. In the first year of the program, 28 teachers from 12 schools and four districts have participated. Although the program enhances learning in many areas of science, several fellows have presented units relevant to conservation biology. These include diversity of life, effects of forestry practices on biodiversity, science and public policy, food webs, alternative energy sources, global warming, acid rain, and oil spills. We provide a synopsis of the different objectives of each unit and the corresponding activities that were used to illustrate them.

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## ARE BIODIVERSITY-RICH COUNTRIES AND BIOPROSPECTING INITIATIVES COMPLYING WITH THE CONVENTION ON BIOLOGICAL DIVERSITY?

In 1992, the Convention on Biological Diversity (CBD) recognized the sovereign rights of countries to control the use of their resources. The CBD was also called the biotrade convention and encouraged countries to develop laws to regulate access to genetic resources. Thus, scientists that are collecting organisms with useful properties had to modify their bioprospecting approaches. Today, these groups must take into account not only the principles stated by the CBD, but also the obligations of national laws that regulate access to genetic resources. Based on two conceptual frameworks, I analyze whether biodiversity-rich countries and bioprospecting groups are complying with the CBD. The results indicate that access legislation has been difficult to implement in some countries. It has become a barrier not only for bioprospecting groups that have commercial interests, but also for scientists who are driven by basic research purposes. Current bioprospecting groups have also failed to propose benefit-sharing packages that ensure the equitable distribution of benefits derived from biodiversity. Technologies transferred by these groups have not met the expectations of local scientists and proposed conservation initiatives need to be improved. Therefore, it can be argued that some countries and bioprospecting groups are not fully complying with the CBD.

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## THE GREATER YELLOWSTONE ECOSYSTEM AS A HABITAT ISLAND FOR MAMMALIAN CARNIVORES: DESIGNING A MULTI-SPECIES RESERVE NETWORK USING INDIVIDUAL-BASED SPATIAL MODELS.

We developed spatial habitat models for the Greater Yellowstone Ecosystem (GYE) for several large and medium-sized mammalian carnivores, including grizzly bear, gray wolf, and lynx. The models, which were constructed using resource selection functions, were used to parameterize a spatially-explicit individual-based model, PATCH, which predicted population viability under current and potential future landscape conditions. Even in species with similar habitat associations, contrasting demography and social structure resulted in divergence in critical regional-scale habitat requirements. For the wolf, incorporating pack structure into the simulation model increased resilience to human-associated landscape change. When added to the species' high vagility, this resulted in effective demographic linkages between the GYE and adjacent regional populations. Similarly for the lynx, relatively low levels of population cycling were found to greatly increase extinction risk when the region was isolated from boreal lynx populations, emphasizing the dependence of the GYE population on broader-scale dynamics. In contrast, regional grizzly bear population viability in the model was most influenced by incremental habitat degradation of potential sink habitats within the GYE. We integrated these contrasting results into a regional multi-species reserve design for the GYE using both the reserve selection program SITES and the PATCH model.

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#### RELATIVE SUCCESS OF INTRODUCED LAND BIRDS ON CONTINENTS AND ISLANDS.

It is commonly reported that introductions of species among different regions have a disparate rate of success. For instance, many researchers state that introductions to oceanic islands are more successful than those to continental mainland regions. This pattern has attracted considerable interest, and several ecological mechanisms have been proposed as its cause. However, the validity of this pattern has rarely been questioned or empirically tested. If some fraction of the disparity simply results from more species being transported to one region than to another, then the observed difference is an artifact rather than an ecological phenomena. Here I test this idea using global land birds, and I show that there is no difference in the success of introduced species between island and mainland introductions. However, introductions within biogeographic regions have been more successful than those between regions and both island size and native geographic range are associated with increasing introduction success.

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#### THE IMPORTANCE OF EPIPHYTES IN BIRD COMMUNITIES: THE CASE OF ARACEAE AND BROMELIACEAE IN A CLOUD FOREST.

Epiphytes provide a variety of resources exploited by birds: fruits, flowers, seeds, water, invertebrates (e.g., in bromeliads "ponds"), nesting materials and nest sites. Here I document the use by birds of various resources provided by four species of bromeliads and three species of aroids in an Ecuadorian cloud forest. I recorded eleven species of birds visiting bromeliads during 580 hours of observation: eight species of hummingbirds visited bromeliads to take nectar and water, and one barbet, one furnariid and one woodcreeper took invertebrates from the clumps of dead leaves or among live leaves. For the aroids (230 hours under observation), I noted that one species of guan and three tanagers feeding on its fruits. While some bird species showed a tight association with the observed epiphytes, the bird-epiphyte interactions did not appear to be highly species-specific. The variety of resources provided by epiphytes to a number of bird species suggest that they may be important contributors to the maintenance of cloud forest bird communities. Furthermore, the bird species recorded may be important seed dispersers and pollination agents for the observed epiphytes.

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#### THE RELIABILITY OF ELASTICITIES OF POPULATION GROWTH RATE.

Demographic models are used in conservation biology to assess population status, to diagnose the causes of population problems, to prescribe management tactics, and to make prognoses of population viability. The sensitivities and elasticities of population growth rate play an important role in these calculations. Sensitivities and elasticities describe infinitesimal perturbations of linear models, but conservation applications involve large perturbations of populations that are subject to density-dependent nonlinearities. We report here a series of analyses to examine the reliability of the usual elasticity calculations. We constructed matrix population models including density-dependent adult survival, juvenile survival, fertility, or development rate, and compared the linear and nonlinear elasticity calculations. The linear calculations are reliable until the nonlinearities become so strong that the population exhibits severely chaotic

behavior. We also examined the effects of making large perturbations of multiple parameters in several published projection matrices. We show that the elasticities do an excellent job of predicting the results of such perturbations, non-infinitesimal though they may be. These conclusions provide additional justification for the use of demographic analysis in conservation biology, especially in situations where only limited population data are available.

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#### MITOCHONDRIAL AND MICROSATELLITE ANALYSES OF WOLVERINE POPULATION STRUCTURE IN MONTANA.

The wolverine (*Gulo gulo*) is the largest of the terrestrial mustelids and least known. Limited scientific knowledge combined with its elusive nature has made the wolverine a management and conservation enigma. The wolverine has declined across most of its range in North America, particularly in the lower 48 states. The largest and most viable population of wolverines in the lower 48 states is in Montana. We are currently assessing genetic variability, gene flow, and population structure of the Montana wolverines using mtDNA sequencing and nuclear DNA microsatellite analysis. A 377 base-pair segment of the mtDNA control region was amplified and sequenced in 67 individuals. Four variable sites defined four haplotypes ( $h=4$ ) with pairwise nucleotide differences of  $d = .0033$ . Pairwise  $F_{st}$  estimates indicated that there is some restricted female gene flow, however an AMOVA analysis failed to detect significant structuring across the state. In comparison, wolverines in the Northwest Territories of Canada had higher levels of haplotype diversity ( $H = .636$  to  $.758$ ) and equivalent nucleotide diversity ( $d = .0018$  to  $.0055$ ). We are currently completing nuclear microsatellite analysis using 10 loci to evaluate genetic diversity and gene flow.

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#### NEST SITE SELECTION OF THE ENDANGERED PALILA (*LOXIOIDES BAILLEUI*) IN A RECOVERING HABITAT.

Understanding nest site selection of endangered birds is important in assessing habitat requirements and recommending recovery strategies. The palila (*Loxioides bailleui*), a Hawaiian honeycreeper, is concentrated in  $<30$  km<sup>2</sup> on Mauna Kea's western slope following decades of habitat degradation by ungulates. While previous studies characterized nest sites in mamane (*Sophora chrysophylla*) prior to (1971-1974), and shortly after (1988) large-scale ungulate removal, this study (1999-2000) focused on nest site selection in the same habitat after more than a decade of low browsing pressure. We found palila nesting higher (4.3m  $\pm$  0.2 vs. 3.9m  $\pm$  0.1) and in taller trees (6.0m  $\pm$  0.1 vs. 5.2m  $\pm$  0.1) than in past decades. Nest trees were significantly taller than trees available in the surrounding habitat. Contrary to previous studies, we found no correlation between nest site characteristics and nest success, suggesting that factors influencing nest fate in recovering habitat may vary over time. Palila also nested in previously undocumented tree and shrub species, and may increasingly use these species as well as large, healthy mamane trees for nesting as the forest recovers.

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#### INTEGRATING GIS AND REMOTE SENSING FOR ECOLOGICAL ANALYSIS OF THE CORBETT LANDSCAPE, INDIA.

Vegetation mapping has been carried out using IRS-1B data. Patch characterization parameters like fragmentation, patch density, juxtaposition, interspersions etc have been studied and presented in this paper. Patch sizes are significantly different in each vegetation type. Sal, Sal-mixed, mixed-sal, miscellaneous and Mixed-bamboo/Bamboo-mixed show higher patch size while pure bamboo shows the minimum average patch size. The dominant forest types viz. Sal, Sal-mixed, mixed-sal, miscellaneous and Mixed-bamboo/Bamboo-mixed show a very high index of shape demonstrating a very high irregularity of the edges of these patches. Interspersion image shows a fairly uniform distributed variation throughout the study area. However central part of the patch shows the homogeneity status, which is mainly due to the presence of pure sal and sal-mixed forests. 80% of the total area is intact. Only 0.35% of the total area towards the southern part shows high interspersions and can be attributed to the presence of varying forest types which are located on a highly varying physiography. The highest juxtaposition index was given by sal forest which accounts for nearly 57% of the total area followed by the non-forest class representing about 26% of the area. It was found that 92.5% of the area has low patch density.

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#### IDENTIFYING HABITAT CHARACTERISTICS AND TREE PREFERENCES OF FRUGIVOROUS BIRDS AS A MODEL FOR BIRD AND HABITAT CONSERVATION.

Identifying habitat associations of bird communities is a crucial first step in conserving avian diversity and -- in the case of important seed dispersers -- in conserving the plant communities on which they depend. A one year study of 13 frugivorous birds in the cloud forests of Ecuador revealed a high degree of both habitat selection and preferences for certain trees. Correspondence Analysis (CA) was performed to determine the habitat variables and tree associations from point counts. Canopy height, tree densities and tree architectures were the variables selected by the model. Small species (tanagers) were found to prefer foraging in lower tree densities, medium size species (tucanets and mountain tanagers) were found in habitats with low canopy height (< 10m) and large frugivorous birds (toucans) were correlated with high tree densities. Bird species selected fruiting trees preferentially with the strongest associations between toucans and Lauraceous trees and guans and Rubiaceae trees. *Ficus* and *Cecropia* fruits were used by many species and likely represent a keystone resource for avian frugivores. Results emphasize the importance of identifying the fundamental associations between frugivores and their foods in conservation planning.

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#### CONTRIBUTION OF LANDSCAPE ELEMENTS TO PLANT DISTRIBUTION IN A MANAGED LANDSCAPE.

The patch-corridor-matrix framework has been widely used in describing landscape structure. Two critical questions are: (1) Should we incorporate additional landscape elements to more conclusively describe the structure?, and (2) How much does each element contribute to the cumulative richness and abundances of plant species? To answer these questions, we conducted inventories of plant species from 1994-2000 within a 28x33 km managed landscape in northern Wisconsin. Of the 333 species detected, 98 (29.4%) were found in all 20 patch types, including the riparian and edge zones. No species were unique to any patch type, but 32 species were restricted to the same eight patch types. The majority of exotic species were found in all 20 patch types, with the exception of bog interior. Our previous studies indicated that past management activities had fragmented the study site to a landscape dominated by areas influenced by edges and roads (>50%). However, we found no species is unique to these patch types. We conclude that a miss-matched relationship exists between species and habitats in this landscape; and the traditional species management approach based on habitat type needs to be revisited.

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#### NATURAL RESOURCE CONSERVATION IN PAPUA NEW GUINEA AND SAMOA WITH THE WORLD BANK.

Papua New Guinea still has 33 million ha of closed natural forest, however logging and forest degradation have been increasing problems. Also, the forest lands are essentially all owned and controlled by local indigenous groups. The World Bank will be assisting the government program to conserve forest resources with a multi-faceted conservation and development project that will have a landowner decision-making unit, conservation trust fund, sustainable forest management, and environmental assessment and monitoring components. With dual goals of improving rural livelihoods and sustainable management and conservation of forest resources, this project involves all levels of society, and goes beyond the existing policy and institutional framework. A cross-sectoral aspect requires that changes to current forest policy occur as a pre-condition for a structural adjustment loan. The project will utilize both participatory, and non-governmental mechanisms in addition to the more traditional government agency institution building. Similarly, other recent World Bank projects have been focused on resource conservation and livelihood improvements through traditional and non-traditional project designs.

CHRISTIANSEN, SARAH, Laura Valutis, Jonathan Loh, Pete Coppolillo, Adam Henson, Jen Divis, and Mohammed Bakarr. WWF-International, Avenue du Mont-Blanc, 1996 Gland, Switzerland (JL), The Nature Conservancy, 2404 Bank Drive, Suite 314, Boise, ID 83705, USA (LV), World Wildlife Fund, 1250 24<sup>th</sup> Street NW, Washington, DC 20037, USA (SC), Wildlife Conservation Society 2300 Southern Boulevard, Bronx, NY 10460, USA (PC), African Wildlife Foundation 1400 16<sup>th</sup> St. N.W. Suite 120, Washington, DC 20036, USA (AH), Enterprise Works Worldwide,

1828 L Street, NW Suite 1000, Washington, DC 20036, USA (JD), Conservation International, 2501 M Street NW Suite 200, Washington, DC 20037, USA (MB).

#### LARGE-SCALE CONSERVATION PLANNING - WHO'S DOING WHAT WHERE?

Several international conservation organizations have individually identified and prioritized globally important areas for biodiversity conservation efforts on a large geographic and temporal scale (e.g. World Wildlife Fund, Conservation International, The Nature Conservancy, Birdlife International, etc.). While these analyses reflect a diversity of criteria and scale, they also show significant overlaps in areas that are – or should be – global priorities for biodiversity conservation. To help understand how we are meeting the ambitious but necessary goals reflected in these global priorities, information from several international conservation organizations is synthesized to understand the larger and landscape scales and areas each organization is currently active in. This poster presentation helps to identify existing or potential gaps in conservation programs in relation to global priorities as well as potential opportunities for greater collaboration. A general overview of each organizations' mission and strategies for large-scale planning is provided. This overlay map and data will be used to inform and promote biodiversity conservation in areas where it is lacking and catalyze greater collaboration amongst existing efforts to avoid duplication and redundancy. The future of global conservation depends on this synergy.

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#### GREAT LAKES FISHERY POLICY: ASSESSING LAKE TROUT CONSERVATION AND SOCIAL CONFLICT RESOLUTION.

Despite its historic role as a top predator, native lake trout stocks (*Salvelinus namaycush*) in the Laurentian Great Lakes have diminished, presenting significant challenges for fisheries conservation. Since 1985, lake trout conservation and management in the Great Lakes has been governed by a court-imposed fisheries management policy—the 1985 Consent Order—due to growing violence between treaty-right Native commercial fishers and non-Native, state-licensed sport fishers over competition for the Great Lakes fishery. This policy utilized a variety of unique provisions to promote conservation and rehabilitation of lake trout while reducing social conflict. To assess the effectiveness of the 1985 Consent Order at achieving its goals, catch data of lake trout were examined and individual, in-depth interviews were conducted with members of the following stakeholder groups: tribal and state biologists; tribal commercial fishers; state-licensed sport fishers; and tribal, state and sport fishing representatives. Under this policy, lake trout abundance increased and violence decreased. However, unsuccessful lake trout fry recruitment and survival remain obstacles for conservation. Proposed reasons for failure include lack of scientific decision-making, TAC limit enforcement, and regulatory flexibility. Importantly, fishing opportunities have diminished for some Native small-boat fishers, which may lead to further conflict in the future.

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#### MOLECULAR PHYLOGENY AND THE CONSERVATION OF THE MANTA RAY, *MANTA BIROSTRIS*.

Manta rays have recently been listed as a protected species in Baja and the Philippines due to conflict between local fisheries and recreational divers who want to protect this charismatic megafauna for eco-tourism. Despite their protected status, manta rays continue to be taken in remote regions. The manta ray is a circumtropical, vagile marine species capable of unlimited dispersal, however photo-identification studies reveal that many individuals are highly site specific. Limited dispersal of individuals would make manta rays highly susceptible to fishing pressure. Molecular sequence data was used to determine the amount of gene flow between locations in the Pacific Ocean and the Gulf of Mexico. While significant population structure was revealed between the Eastern and Western Pacific samples, no structure was found within either region. The low nucleotide sequence divergence within the Western Pacific suggests a recent founding of the Western Pacific from an unknown source. While protection for this species is warranted based on photo-identification studies, molecular analysis was not able to detect limits to gene flow within the Eastern or Western Pacific.

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#### COMMUNITY RESPONSE TO LARGE SCALE DISTURBANCE IN BORNEAN BUTTERFLIES.

During severe El Niño Southern Oscillation events large-scale fires may severely effect tropical lowland rainforests. Although the effects of fires are poorly known a large proportion of remaining forests have already been affected. Both logging and fires increase the probability of future fires. When a landscape is affected by fire or logging we expect a

breakdown of the original habitat. Other research has shown that original habitat breaks down from a single continuous patch to several patches when 60% of the original habitat is still present. In landscapes with a low proportion of original habitat (< 20%) additional loss will result in an exponential increase in distance between patches of original habitat. Patch isolation and size are not linearly related to the proportion of original habitat, but experience rapid changes at critical proportions of original remaining habitat. Butterflies make excellent bio-indicators for forest disturbances. Data is presented on community response to single and multiple disturbance events between ecotypes within an ecoregion and between ecoregions with different disturbance histories. There is a positive response (species richness) due to a single disturbance event within an ecoregion, but a dramatic negative response as an ecoregion is subjected to additional large scale disturbance events.

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**PHYLOGEOGRAPHY AND CONSERVATION GENETICS OF THE ENDANGERED BRAZILIAN TREE SPECIES *CARYOCAR BRASILIENSE* Camb. (CARYOCARACEAE).**

*Caryocar brasiliense* is an endangered Cerrado tree species, with high ecological and economic importance. Cerrado fragmentation, the commerce of fruits, and the high frequency of fires due to agricultural practices have been affecting population dynamics of the species. We report the population genetic structure and phylogeography of *C. brasiliense*, based on variability at nuclear and chloroplast microsatellite loci, and discuss the potential consequences for conservation. Chloroplast based network showed four distinct clusters, but major breaks among populations were not related to current geographical barriers. Low haplotype diversity within populations were found for cpDNA polymorphisms, in sharp contrast to the high diversity within and modest differentiation between populations found for nuclear markers. Our results support the hypothesis of restriction of ancient populations to moist refugia during extended droughts coinciding with glaciations in the Northern hemisphere and a subsequent spread to favorable areas throughout Central Brazil. Seed dispersal has been restricted to local populations, and gene flow occurred mainly by pollen movement, due to the extinction of dispersers and current isolation of populations. The comparison of the distribution of genetic variability in the nuclear *versus* cpDNA microsatellites allows an in depth understanding of the genetic structure and provide important information for conservation.

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**SPATIAL DYNAMICS OF THE GIANT KANGAROO RAT (*DIPODOMYS INGENS*): A PROPOSAL FOR MANAGEMENT AND TRAPPING.**

The Carrizo Plain Natural Area (CPNA), California is not only one of the last refuges for many federally listed endangered species but also a representation of what California's San Joaquin Valley once was. The Giant kangaroo rat (*Dipodomys ingens*), a keystone species, is one of several federally listed species on the CPNA. Information on the spatial organization of *D. ingens* is limited. We radio tracked 20 animals in summer of 1999 and 17 animals in winter 2000 to assess the spatial dynamics of this solitary rodent and provide recommendations for trapping and management strategies. In the summer, *D. ingens* remained predominately at their home burrows. During the winter breeding season, males visited female's burrows and home range overlap increased. Female average home range sizes during both seasons were .03 ha. Males averaged .02 and .10 ha for summer and winter, respectively. Nearest neighbor distances were 2-5m. To gain accurate census estimates we recommend trapping at active burrows or, when trapping in lines, set traps every 5 meters. Since *D. ingens* occurred at healthy densities during both field seasons, (48 animals/ha) we recommend these results as the model for space requirements of this species.

COPPOLILLO, PETER B., Eric W. Sanderson, Amy Vedder, Robert B. Wallace, R. Lilian E. Painter, Humberto Gomez, Jeffery P. Jorgensen, Amanda B. Jorgensen, Bryan Curran, Fiona Maisels, Paul Elkan, and Sarah Elkan. Wildlife Conservation Society, International Conservation, 2300 Southern Blvd., Bronx NY 10464-1090, USA, (PBC, EWS, AV), Wildlife Conservation Society, Casilla 3-35181, San Miguel, La Paz, Bolivia (RBW, RLEP, HG), Wildlife Conservation Society, Mariscal Foch 635 Y Reina Victoria, Oficina 2B, Casilla 17-21-168, Quito, Ecuador (JPJ, ABJ), Wildlife Conservation Society, B.P. 14537 Brazzaville, Congo (BC, FM, PE, SE).

**USING THE LANDSCAPE SPECIES APPROACH TO FOCUS CONSERVATION ACTION: DATA FROM CONGO, ECUADOR AND BOLIVIA.**

The landscape species approach provides a wildlife-based framework for site-based conservation in heterogeneous landscapes. Conservation actions are prioritized by identifying spatially and temporally explicit intersections (and

conflicts) between human activities and the requirements of landscape species. Suites of landscape species were selected for three sites: Madidi National Park in northwestern Bolivia, Yasuní National Park in eastern Ecuador, and Nouabalé-Ndoki National Park in northern Congo Republic. At each site, the spatial distributions of requirements for each landscape species were mapped at appropriate temporal scales and overlaid on distributions of human activities for the same periods. Based on these analyses, ‘focal landscapes’ were identified for conservation action at each site. In all three cases the landscapes identified for conservation action differed from those predicted by a traditional ‘core-buffer-corridor’ model. The subset of threats identified as ‘critical’ was also substantially smaller than the suite of all threats identified for each of the three landscapes. While the ultimate tests of the long-term utility of the landscape species approach will be ecological and performance monitoring data, the approach appears to be an effective way to focus site-based conservation efforts in large and heterogeneous landscapes.

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#### RESOURCE PARTITIONING AMONG NATIVE HAWAIIAN DRY FOREST TREES.

Hawaiʻi's dry forests are among the most endangered of all ecosystems in the archipelago. Unfortunately, these once extensive and diverse communities have been severely fragmented and degraded by deforestation, development, fire, nonnative ungulate grazing, and invasions by alien plant species such as fountain grass (*Pennisetum setaceum*). Understanding factors such as determinants of growth, water relations, and seasonal patterns of phenology can help us interpret current forest composition and evaluate the threat of invasive species. We studied the mechanisms for partitioning limited water sources of seven co-existing dominant trees from the Kaupulehu dry forest preserve on the island of Hawaiʻi. Species such as *Diospyros sandwichensis* and *Santalum paniculatum* exhibited more negative stem water potential and lower rates of net photosynthesis during periods of low soil moisture availability while making opportunistic uses of water when available. In contrast, other species such as *Colubrina oppositifolia* maintained more positive values of stem water potential with relatively high rates of photosynthesis over a large range in soil moisture availability. This may be attributed to the ability to tap deep sources of soil water during periods of drought. These results point to spatial and temporal partitioning of resources among Hawaiian dry forest canopy tree species.

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#### RECRUITING SCIENTISTS FOR PRIORITY CONSERVATION RESEARCH.

The Nature Conservancy strives to obtain and utilize the best available scientific information to influence conservation planning and land management. To that end, the Hawaiʻi office (TNCH) works cooperatively with scientists in government, academia, and the private sector. However, land managers have expressed concern that some research is inadequately targeted to address immediate conservation management needs. Therefore, starting in 1997, TNCH managers and biologists compiled a list of priority research needs that were designed to better link researchers and managers. The Secretariat for Conservation Biology promulgated this list, which was made available to the graduate students, in the Ecology, Evolution, and Conservation Biology (EECB) program at the University of Hawaiʻi, many of whom intend to pursue careers in conservation. This list has been updated annually to reflect changing management concerns, and the format has evolved to describe the expected management application of each potential study. In Fall 2000 the list was posted to the EECB web site for easy access by researchers outside Hawaiʻi. A dozen research projects have been undertaken that reflect topics on the research needs list. This research has provided valuable data and guidance to improve management of Hawaiian ecosystems. Some instructive examples are briefly reviewed.

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#### FUNDING OPPORTUNITIES AT THE NATIONAL SCIENCE FOUNDATION.

The National Science Foundation is charged with facilitating the health of the scientific enterprise in the US. It does this by providing funding for research and education in science and engineering. Clear understanding of this role and the opportunities provided by the NSF serves both the scientific and public communities. Information will be provided on the nature of NSF support, with emphasis on funding opportunities in the biological sciences. A handout with descriptions and URLs of relevant NSF competitions will be provided.

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## HOW DO DIFFERENT INSULAR TROPICAL STREAM ECOSYSTEMS FUNCTION?

Tropical insular rivers are relatively short in length and have small, linear drainage patterns rather than large reticulate networks found on continents. Isolated insular freshwaters generally have fewer native species than mainland rivers. For example, the diversity of aquatic insects is often low because of their limited dispersal ability. Insular headwaters are frequently dominated by native species of gobies, neritid snails, as well as atyid and palaemonid shrimp. These species are widespread because their larvae drift in oceanic currents to many different estuaries and migrate up rivers. Low-diversity insular streams are also highly vulnerable to human-introduced species. Consequently, food webs are often complex assemblages of relatively few native species mixed with variable combinations of non-native species. These ecosystems provide opportunities for studies of major ecological questions. How do food webs function with relatively reduced redundancy? How resilient are these communities to highly variable flow conditions? Studies of tropical streams on Caribbean and Pacific islands are providing new insights regarding energy flow through complex species assemblages. Geographic and temporal comparisons illustrate how food webs reorganize and respond to extreme hydrologic events such as floods and droughts. Understanding these dynamic responses is essential for managing native species and their highly variable habitats.

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## DECLINE AND HOMOGENIZATION OF PACIFIC FAUNAS: THE LAND SNAILS OF AMERICAN SAMOA.

Native Pacific island land snail faunas are highly diverse and exhibit high levels of endemism but are also severely threatened. Many alien snails are being introduced, leading to faunal homogenization across the Pacific. Field work in American Samoa aimed to evaluate this homogenization. We detected 19 of the 42 previously recorded native species, 11 of 12 aliens, and 3 of 6 cryptogenic (unknown origin) species. We recorded 8 species from American Samoa for the first time (3 described and presumed native, 4 alien, 1 cryptogenic); 2 undescribed endemics; and one unidentified species. We discovered 1 species previously considered extinct. Comparisons with surveys in the 1920s and 1930s, 1975, and 1992 showed that: most native species are declining; a few native species may be stable or increasing, with 1 species abundant; only 7 of the alien/cryptogenic species are declining, while 6 are increasing; for others no trend was assessed; some aliens are extremely abundant. Threats include: alien predators, predominantly rats and predatory snails; possible competitors, including alien snails; invasive plants and habitat modification; development, including recreational, agricultural, and domestic/urban development. The diverse and highly endemic native fauna is being replaced by a small number of pan-tropical aliens.

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## COLONIZING PATTERNS OF A RESTORED POPULATION IN EASTERN KENTUCKY.

Restoration of large mammals is often controversial and policy may require animals to be confined to "restoration zones." Predicting post-release movements of translocated animals may enhance restoration success. Restoration of elk (*Cervus elaphus nelsonii*) to the Cumberland Plateau region of Kentucky began in the winter of 1997, and population augmentation has continued for the past 4 years. We used multiple linear regression to determine what landscape and demographic variables influence post-release movements of translocated elk. Most animals moved between 2-20 km from their release sites. Movements were limited by roads and natural barriers. Adults moved significantly farther than yearlings. Eighty-one percent of the animals that traveled >30 km were adult females. Early population growth is enhanced by translocating pregnant females, however, 5% of the population leave the release area during colonization behavior associated with parturition. Such losses from the population and colonization-related Allee effects may be ameliorated if the founder population is large or multiple release sites are used.

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## EVOLUTION OF RUNNING WATER HABITATS ON HOTSPOT ISLAND ARCHIPELAGOS.

As a hotspot island forms and proceeds through the shield-building phase and senesces into an atoll (4-6 Mya), running water habitats change. Observations from Society, Marquesas and Austral Islands, and Rarotonga, Cook Islands, indicate that original lotic habitats were small heavily shaded streams. More specialized flows developed at early mid age (1.0 Mya) then, in old age, again to smaller shaded streams but with smooth rock chutes. Importantly after the shield building phase were regular eruptions associated with erosion of the magma chamber. Nonconformities between lava layers resulted in springs on cascade faces and elsewhere. Further, eventual collapse of the caldera provided sufficient catchment area for formation of large rivers. Rainfall is fundamental to lotic habitats and while related to island altitude and area, is influenced by climatic region. Lotic habitat evolution will be overlaid on a reconstructed phylogeny of a subgenus of central-Pacific black flies (Simuliidae). Larvae of these flies require

permanent running water and some species need highly specialized habitats. The specialized habitats are normally found on younger islands, hence age of aquatic habitats influences biogeography of these simuliids - younger highly derived species cannot colonize older islands because the required habitat is not available.

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#### FUNDING BIODIVERSITY CONSERVATION: MOVING BEYOND SUPPLY TO ATTRACTING DEMAND.

Achieving adequate funding for biodiversity conservation is important for success. Biodiversity loss is a worldwide problem that is exacerbated by a lack of community understanding and finances. Often run primarily as a supply-driven government monopoly, conservation rarely ranks as a high government economic priority or rarely attracts private investment. Because conservation can deliver both public and private benefits, the future of biodiversity conservation must include determination of attitudes and willingness to invest in conservation. This paper reports on such a study in New Zealand. This survey of visitors to three different conservation sites showed that the public desire more conservation while expecting taxes to achieve much of this. In addition, those that enjoy conservation experiences favour conservation the most and are prepared to pay directly. Currently most tourists are forced to behave as takers of biodiversity, yet it is likely that these people would change to investors if mechanisms were available and the income was used to sustain biodiversity as well as enhance visitor experience. A lack of informed debate and supply oriented organisational structures appear to deny sustainable biodiversity gains and public satisfaction.

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#### COLONIZATION OF LAKE ONTARIO BY INTRODUCED PACIFIC SALMON.

Non-native Pacific salmon released from hatcheries have been a major component of the Lake Ontario recreational fishery for 30 years. The hatchery-produced Chinook and Coho were not anticipated to colonize because they lacked the stream-specific environmental cues that would drive them to return to their natal streams to reproduce. Recently, however, thousands of mature adults have begun entering the stream watershed to spawn. In addition, juveniles have been found in streams. Thus, it is possible that alien Pacific salmon are now colonizing Lake Ontario. The history of stocking alien species into Lake Ontario is well documented and we have good data on the environmental changes occurring in the watershed over that period including changes in the biotic community induced by exploitation and invasions by other species. Using GIS and other statistical methods, we relate the recent pattern of colonization by Pacific salmon to a variety of environmental factors, including changes in the levels of disturbance, pollution, community dynamics and watershed rehabilitation. We predict that natural reproduction by Pacific salmon will increase to the point where it will have a significant impact on fisheries management and affect restoration efforts to restore native biodiversity in the Lake Ontario ecosystem.

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#### EVOLUTIONARILY SIGNIFICANT UNITS: GENETIC AND ECOLOGICAL COMPONENTS FOR CONSIDERATION.

The ESU concept has evolved significantly since its first inception to recent definitions by Moritz. These changes are associated with which biological properties to emphasize and/or de-emphasize in the designation of distinct populations for conservation status. Here I explore some of the similarities and differences among various concepts, the differential use of the ESU concept in practice, and make recommendations for the incorporation of ecological and genetic data in a multifaceted framework for describing various levels of population differentiation.

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#### THE THREE GORGES DAM IN CHINA: CONSERVATION CHALLENGES AND REFLECTIONS.

A delegation of 12 spent two weeks in China to explore and learn about the history, progress, and future of the Three Gorges Dam (TGD) that is currently under construction across the Yangtze River. The 185m-high TGD is the largest hydroelectric project in the world and will create a 660 km long reservoir. Sedimentation and flow alterations above and below the dam will be a major problem for engineers and local flora and fauna alike. The dam will also have less

tangible consequences on the scenic and ecological value of the TGD. Major human activities such as coal mining, deforestation, agriculture, and factory production along the riverside have already produced much damage to the river ecosystem. Yet, ecological baseline data (e.g., species lists) of both the terrestrial and aquatic systems are limited. To promote conservation of the giant river ecosystem and many associated rare and endangered species (e.g., river dolphin, Chinese sturgeon, etc.), we call for increasing communications among all parties involved in the project, development of an adaptive management framework for the river and its watershed, and rapid development of a database and monitoring program before pre-construction information about the Gorges and the River vanish.

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#### INBREEDING DEPRESSION IN THE WILD.

Despite its practical application in conservation biology, the cost of inbreeding in natural populations remains to a large degree unknown. In this review we have gathered estimates of inbreeding depression from the literature for wild species monitored in the field. Our data set includes seven bird species, nine mammal species, four species of poikilotherms and 15 plant species. Mean inbreeding depression  $\pm$ SE for homeotherms was  $0.509 \pm 0.081$ ; for poikilotherms,  $0.201 \pm 0.039$ ; and for plants,  $0.331 \pm 0.038$ . Levels of inbreeding depression this high will be biologically important under natural conditions. We compared our mammalian data (traits related to juvenile mortality) to estimates for zoo species published by Ralls et al. (1988) to determine if, as hypothesized, natural estimates of inbreeding depression are higher than captive estimates. The cost of inbreeding in mortality traits for wild mammals corrected for  $F=0.25$  (as is the case for Ralls et al.), was substantially and significantly higher than that for captive species (2.155 compared to 0.314). Therefore, the cost of inbreeding is 7 times larger in the wild compared to captive conditions. 53% of the estimates gathered were significantly different from zero, indicating that inbred wild species frequently exhibit moderate to high levels of inbreeding depression in fitness traits.

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#### EXTINCTION AND COLONIZATION OF BIRDS ON HABITAT ISLANDS IN URBAN SOUTHERN CALIFORNIA.

We used point count and transect surveys to estimate the distribution and abundance of eight scrub-breeding bird species in 34 habitat fragments and the urban matrix in southern California. We then calculated local extinction and colonization rates by comparing our data with surveys conducted in 1987. We classified factors that influence extinction and colonization rates into two types: (1) extrinsic factors, characteristics of the habitat fragments (area, age, and isolation), and (2) intrinsic factors, characteristics of the species that inhabit fragments (body size and population density). Over the past decade, at least one species went locally extinct in over 50% of the fragments, and local extinctions were almost twice as common as colonizations. Fragment size and to a lesser extent fragment age were the most important extrinsic factors determining extinction and colonizations. Density indices of scrub birds were the most important intrinsic factors determining extinction rates, predicting the number of sites occupied, probability of local extinction, relative area requirements, and time to local extinction.

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#### ENDANGERED SPECIES RECOVERY AND THE SCB STUDY: THE U.S. FISH AND WILDLIFE SERVICE PERSPECTIVE.

Several current and former U.S. Fish and Wildlife Service (USFWS) biologists provide their perspective on endangered species recovery planning and the comprehensive recovery planning study recently conducted by the Society for Conservation Biology (SCB). After considering the review findings and recommendations, and real-life constraints and limitations the USFWS regularly faces, the authors identified six key areas that they believe have the greatest opportunity to improve the quality and effectiveness of recovery plans: (1) Continue to expand ties to academic and professional communities; (2) Increase efforts to expand the diversity of recovery plan contributors; (3) Expand training opportunities for USFWS employees; (4) Revise guidance on developing recovery plans; (5) Improve

access to information on emerging theories, techniques, and technologies; and (6) Address key policy questions raised by the SCB recovery plan review papers. Furthermore, the authors identified a need to increase the internal consistency of recovery plans; improve species-specific details in multi-species recovery plans; standardize criteria for determining when recovery plans need revision; and improve the treatment of monitoring in recovery tasks. The authors also identify several policy issues the USFWS may want to address.

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OCEAN MANAGEMENT AT MIDWAY ATOLL: RELATIONSHIPS BETWEEN DIVING, FISHING, AND GALAPAGOS SHARKS.

As part of its management plan for Midway Atoll National Wildlife Refuge, the U.S. Fish and Wildlife Service combines the protection of endangered avian and marine species with ecotourism ocean recreation. At Midway snorkeling, diving and tag-and-release fishing are all in close proximity to each other, and shark-human interaction occurs during all of these activities. Midway is a remote location—2,100 km from Hawai'i. Its protected coastal environment has a large population of juvenile Galapagos (*Carcharhinus galapagensis*) and gray reef sharks (*C. amblyrhynchos*). In order to understand potential interactions we determined the sex, size and movement patterns of Midway's shark species, which are regularly attracted to diving and fishing locations. Both male and female sharks in a 1:1 sex ratio were captured, tagged, and measured before being released. They ranged in size from 87 to 118 cm total length. Sharks tagged at fishing sites were later observed at dive sites, and, based on tagged shark resightings, sharks moved freely between existing diving and fishing sites. A thorough understanding of shark movement patterns, growth rates, and reaction to dive boats and divers is needed for effective refuge management and ocean-recreation safety at Midway.

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EFFECTS OF THINNING AND PRESCRIBED BURNING ON PONDEROSA PINE FOREST BIRDS IN THE COLORADO FRONT RANGE.

The foothill ponderosa pine forests along the Colorado Front Range are an important, unique and understudied habitat. Ponderosa pine forests are important to a variety of wildlife species, including Neotropical migrant and resident songbirds. Specific stands of ponderosa pine on City of Boulder Open Space are slated for thinning and/or burning in accordance with the City of Boulder's management objectives. As part of this goal, in the spring and summer of 2000, we set up 6 study sites and gathered data on abundance, diversity and nesting success of Neotropical migrant birds. Our data describe the pre-treatment avian community present in each plot and the appropriate management for enhancing this community. Our data show that two of the plots support a depauperate avian community and a low rate of nesting. As a result, they offer a great opportunity for use of more extreme management measures. Two additional plots show a diverse and abundant breeding bird community so lower intensity management will be appropriate for these stands. Finally, the two control sites adequately reflect a healthy, diverse bird community and therefore will serve as appropriate controls for the four treatment stands in future comparisons of bird community responses to management.

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FEATHERS AND SCALES: FOREST BIRDS AND LIZARDS ON THE NORTHERN ISLANDS OF THE MARIANAS ARCHIPELAGO.

The herpetofauna and forest avifauna of the Northern Islands of the Marianas Archipelago have not previously been systematically documented. Only 8 forest bird species are known from the Northern Islands, compared with 16 from the southern islands of the chain. In June–August 2000 we surveyed six islands to the north of Saipan. We estimated forest bird populations using Variable Circular Plot methodology and documented the presence of reptiles using adhesive rodent traps, loop-snare traps, and visual surveys. We recorded two island firsts for lizard species: the rock gecko, (*Nactus pelagicus*) on Alamagan, and the tide-pool skink (*Emoia atrocostata*) on Alamagan and Guguan. The resulting bird population estimates are the first for forest birds on these islands. We found that populations of Micronesian Honeyeaters (*Myzomela rubratra*) and Micronesian Starlings (*Aplonis opaca*) were wide-spread and abundant. Micronesian Megapodes (*Megapodius laperouse*) were also present on all islands, but abundance was related to presence or absence of feral animals. Other birds exhibited disjunct distributions, including the endangered Nightingale Reed-warbler (*Acrocephalus luscini*). The Northern Islands have the potential, through translocation and

establishment of new populations, to guard the archipelago's biodiversity should an infestation of Brown Tree Snake (*Boiga irregularis*) occur.

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ENVIRONMENTAL DEGRADATION, COASTAL ECOSYSTEMS AND HUMAN COMMUNITIES IN NORTHWESTERN MEXICO.

The growth of the commercial, export-oriented agriculture, fishing and aquaculture industries are currently contributing to the degradation of coastal ecosystems in northwestern Mexico. Agricultural runoff and shrimp pond wastes usually end up in the many lagoons and estuaries found in the region, affecting water quality, mangrove forests and aquatic organisms. Habitat fragmentation is now a common process found in these coastal ecosystems. This research also examines the implications of natural resource degradation for the human population who inhabits the region. The results of the study show that local households have developed a set of responses to cope with the various problems posed by environmental degradation. The study concludes that management policies integrating the knowledge and socio-cultural characteristics of the local population are indispensable for the sustainable development of agriculture, aquaculture and fishing industries, and for the conservation of coastal ecosystems in northwestern Mexico.

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PARASITES, DISEASE AND CONSERVATION OF ISLAND ENDEMIC: LESSONS FROM THE *PARTULA* SNAILS OF POLYNESIA.

Tree snails of the genus *Partula* were extirpated from much of their South Pacific island range following the introduction of a predatory snail, *Euglandina rosea*, as a biocontrol for feral alien *Achatina* snails. Many *Partula* spp. are critically endangered and over 10 occur solely in captivity, where populations undergo periodic crashes suggestive of infectious disease. Here we report an emerging disease of partulid snails caused by a new species of microsporidian parasite. This disease caused a population crash to extinction of *Partula turgida* - the first proven case of extinction by infection. The origins of the parasite are currently unknown, but possibilities include allopatric hosts encountered in captivity, co-introduction to Polynesia with alien hosts, or endemism in one or more species of partulid snail. We demonstrate an association between microsporidian infection and increased mortality in *P. turgida*, but not in three other infected *Partula* spp., although parasite-induced disease was present in individual snails. The reasons that infected populations of these species, but not of *P. turgida*, appear unaffected remain unknown, but one possibility is that they co-evolved with the parasite. Further work is urgently required to determine the prevalence and impact of microsporidian infection in other *Partula* spp.

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CONSERVATION STATUS AND THREATS TO ISLAND-ENDEMIC MOCKINGBIRDS AND ALLIES.

The family Mimidae includes several island-endemic forms that are among the world's most endangered avian taxa. I reviewed available information to assess whether these species face common threats. The Floreana Mockingbird (*Nesomimus trifasciatus*) disappeared from Isla Floreana (Galápagos) in the late 1800s due to predation and habitat degradation caused by introduced mammals; it persists on two mammal-free islets with a total population of < 200 individuals. Barring mammalian introductions, continuing threats include El Niño-associated climatic variability, and demographic and genetic stochasticity. Introduced mammalian predators and grazers likewise account for the decline of the Socorro Mockingbird (*Mimodes graysoni*) to < 350 individuals. Cyclones, potential for hybridization, and lack of formal habitat protection represent additional threats. White-breasted Thrashers (*Ramphocinclus brachyurus*) total < 200 birds on St. Lucia and Martinique. On both islands, anthropogenic habitat loss may compound effects of introduced predators; hurricanes are an additional threat given severe range contraction. Concern exists regarding three additional endemics (Cozumel Thrasher, *Toxostoma guttatum*; San Andres Mockingbird, *Mimus magnirostris*; and Tres Marias Blue Mockingbird, *Melanoptila caerulescens longirostris*) because of hurricanes, introduced mammals, and habitat loss; however, basic ecological data for these taxa are lacking. Other island mimids are comparatively safe where common threats are absent.

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## IMPLICATIONS OF THE NATIONAL WILDLIFE REFUGE SYSTEM IMPROVEMENT ACT FOR CONSERVATION LAND ACQUISITION.

The National Wildlife Refuge System is the only federal system of lands devoted to wildlife conservation in the United States. The importance of the Refuge System to biodiversity conservation rose immensely as a result of the National Wildlife Refuge System Improvement Act of 1997. Among other things, the Refuge Improvement Act: 1) provided a unifying mission for the Refuge System; 2) mandated the maintenance of biological integrity, diversity and environmental health on the Refuge System; 3) calls for the Refuge System to contribute to the conservation of the ecosystems of the United States. Policies have been developed that elaborate the mission of the Refuge System and the maintenance of biological integrity, diversity, and environmental health. For purposes of contributing to the conservation of the ecosystems of the United States, an ecosystem conservation component was added to the U.S. Fish and Wildlife Service's Land Acquisition Prioritization System (LAPS), which is used to score potential acquisitions for developing budget proposals pursuant to the Service's trust responsibilities. For the conservation estate at large, a transdisciplinary approach that integrates natural and social sciences may help to assess in holistic terms the relative conservation merits of lands and, therefore, to optimize conservation land acquisition strategies.

## DAEHLER, CURTIS C. Department of Botany, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA. POPULATION ECOLOGY OF AN INVADING GRASS *VERSUS* A NATIVE COMPETITOR: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT.

In Hawai'i, African fountain grass (*Pennisetum setaceum*) is a highly successful invader that has displaced native pili grass (*Heteropogon contortus*) from many arid lowlands. Both species are fire adapted, perennial C4 bunchgrasses that rely on apomictically produced seeds for population growth. To gain insights into why the invader has been more successful than the native, we compared the reproductive ecology and growth responses of these species under various conditions. We found that seeds of the invader germinated faster than those of the native. Likewise, seedlings of the invader grew faster, particularly in nitrogen-rich soils. Seed production by the invader averaged 6-fold greater than the native under high-to-moderate water and nutrient conditions. Nevertheless, some conditions favored the native: under drought and low nutrient conditions, the invader failed to produce seeds. The native's seedlings also had higher drought tolerance than those of the invader. In composite, these findings help explain the native's current restriction to some of the driest, nutrient-poor habitats in Hawai'i while also suggesting that these habitats are suitable for pili grassland restoration because of natural resistance to fountain grass. The spread of alien nitrogen-fixing legumes into these habitats may exacerbate attempts to maintain or restore native pili grasslands.

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## "CO-EXTINCTION" IN THE *PARTULA* SNAIL CONSERVATION PROGRAM?

Tree snails of the genus *Partula* have undergone a series of dramatic extinctions over the last two decades, following the introduction of predatory snails throughout their Polynesian range. Captive breeding is critical for the survival of this group of island endemics, which contains over 10 species that are extinct in the wild but still exist as small captive populations. We repeatedly found high numbers of a diverse assemblage of flagellated protozoa in the gut of captive and wild-caught snails. Fluorescent microscopy demonstrates that these protozoa ingest particulate matter and are likely to be non-parasitic commensals. Newborn mortality is higher in generations with low flagellate prevalence. We conclude that these protozoa may assist digestion of the snails cellulose-rich diet. Prevalence and diversity of flagellates is significantly higher in wild caught snails and decreases significantly with each generation in captivity. These data suggest that captive management should be modified counter-intuitively, so as to increase flagellate transmission rates and prevent their permanent loss from captive stocks. Furthermore, they highlight the need for consideration of parasite conservation and "co-extinction" rates in *ex situ* conservation programs.

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## RECOVERY OF TUATARA ON LITTLE BARRIER ISLAND, NEW ZEALAND: SCIENCE MEETS POLITICS.

Little Barrier Island is a 3083 ha volcanic island in the Hauraki Gulf, New Zealand. Its biological richness - rare birds, bats, mega-invertebrates, and kauri forests - makes it one of the most significant wildlife reserves in New Zealand, but the island is seriously degraded by the presence of introduced Pacific rats (*Rattus exulans*), which threaten many of the rarest species. A remnant population of tuatara (*Sphenodon*), an ancient reptilian lineage endemic to New Zealand, was re-discovered on Little Barrier Island in 1991. We report on the progress of recovery programs for this

population, which have successfully met the following scientific challenges: (1) protection of the 8 surviving tuatara from rat predation; (2) assisted reproduction of these survivors, resulting in approximately 60 hatchlings now in a head-start facility; (3) confirmation of the pattern of temperature-dependent sex determination and its consequences for population recovery; and (4) determination of the taxonomic status of the population. The primary remaining obstacle to long-term recovery of tuatara and other rare species on Little Barrier Island is the persistent failure of management authorities and indigenous M ori people affiliated with the island to establish a working relationship that will allow eradication of Pacific rats.

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#### AN ENDEMIC ISLE ON AFRICA'S SOUTHERN TIP: THE AQUATIC FAUNA OF THE CAPE FLORISTIC REGION.

An area of outstanding conservation importance the Cape Floristic Region is recognized as a region of extreme floristic species richness and endemism. Considering the CFR as an island of varying size, many of its aquatic ecosystems act as islands, isolated from each other for millions of years. We hypothesize that these effects contribute substantially to the narrow distribution ranges and extreme endemism within the aquatic fauna. Analyses show that while species richness of aquatic invertebrates may not be comparable to that of the vegetation, levels of endemism are greater. Morphological revisions, increasing data synthesis and molecular techniques have lead to greater recognition of endemism within this important biological repository. MtDNA data for some lotic species reveal some of the highest levels of intra-specific divergence recorded, pointing to possible species flocks. Spared climatic oscillations experienced across the rest of the continent and the effects of glaciation, this region has remained relatively stable over the past 200 MY allowing the formation of myriad water bodies, variable in physical and chemical characteristics. Strong orographic gradients and edaphic diversity, oligotrophic and often seasonal or ephemeral water bodies all impose strong selective pressures. These factors have provided environments enabling an array of endemic species.

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#### *DIPODOMYS INGENS*: KING OF THE PLAIN? PREDATION PRESSURE AND FOOTDRUMMING ON THE CARRIZO PLAIN.

The endangered kangaroo rat, *Dipodomys ingens*, exists on 2% of historic habitat on the Carrizo Plain Natural Area (CNPA) in California. A keystone species, *D. ingens* is prey to owls, snakes, weasels, coyotes and the endangered kit-fox. In predator encounters, *D. ingens* footdrums, a well known and highly efficient way to combat snake predation. Footdrumming is seen anecdotally in encounters with kit-fox (*Vulpes macrotis*), its primary mammalian predator, but has not been reported for other mammalian predators. Coyotes (*Canis latrans*) and kit-foxes compete for food items, including *D. ingens*, on the Carrizo Plain. As human encroachment increases, driving more predators onto CNPA and increasing competition, how may *D. ingens* respond to burgeoning numbers and types of predators? Our study tests the anti-predator response of *D. ingens* to mammalian predation. We introduced a taxidermy kit-fox and a stuffed tiger, representative of non-specific four-legged predator, to sixteen individuals on the Elkhorn Plain within CNPA. In predator avoidance tests, *D. ingens* did not avoid either predator. Predator recognition tests indicate *D. ingens* may footdrum in response to four-legged predator and not specifically to kit-foxes. This ability to adapt anti-predator behavior may maintain *D. ingens*' ecological viability under continually changing predation pressures.

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#### GENE FLOW BETWEEN 'SUBSPECIES' OF CAPTIVE RED PANDA -- BRIDGING THE GAP, OR BURNING THE BRIDGE?

The red panda, *Ailurus fulgens*, is endangered in the wild because its declining population is severely fragmented (IUCN Red List). Zoos have developed a long-range captive management plan (SSP) as insurance against species loss, but require genetic information to prevent inbreeding or outbreeding depression. Animals collected from both extremes of red panda distribution across the Himalayas (19-20 each) have been managed separately as purported subspecies. In nature, western animals (*A.f. fulgens*) may be near extinction due to human encroachment. Heightened efforts to preserve captive *A.f. fulgens* also raise concerns about loss of genetic diversity from founder effects in long-term breeding. Managers are therefore considering crossing western with eastern animals (*A.f. styani*), but must

understand potential consequences. We sequenced a 330-bp segment of the cytochrome *b* gene of red panda mitochondrial DNA from a small sample of zoo animals to determine genetic divergence between the subspecies. We observed five haplotypes – one shared by both subspecies, one exclusively found in *fulgens*, and the other three found only in *styani*. These results suggest that subspecific classification is still inconclusive, and that additional sampling of individuals and DNA segments is required before managers can be advised on interbreeding red panda subspecies.

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#### THE TERAJ ARC: A LANDSCAPE-SCALE PLAN TO CONSERVE WILD TIGERS IN LOWLAND NEPAL AND INDIA.

The subtropical jungles to the south of the Himalayan foothills in Nepal and India, known as the Terai Zone, support perhaps the densest populations of tigers on Earth. Tiger populations are protected in a network of 11 national parks and wildlife reserves. The biology of tigers and their prey in several of these reserves have been studied in detail. Only one of the 11 reserves is larger than 1000 km<sup>2</sup> and none currently supports more than 60 breeding adults. The small size of the reserves poses a serious obstacle for long-term tiger conservation: despite their large size, ability to swim, and large home ranges, tigers are relatively poor dispersers. Empirical data from India indicates that tigers are reluctant to cross gaps greater than 5 km of human-dominated landscapes. Existing forest corridors have the potential to reconnect all 11 reserves, although there are a few major dispersal bottlenecks requiring restoration. We created a landscape-scale conservation plan, the Terai Arc, designed to manage tigers as a single metapopulation spanning a range of almost 800 km. We identify the steps now underway to make the Terai Arc the most ambitious wildlife recovery program in Asia.

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#### MARINE RESERVES: ARE THERE ANY LESSONS TO BE LEARNED FROM TERRESTRIAL RESERVE SYSTEMS?

The last fifty years of the 20th century produced legislation that set a significant area of land for the preservation of terrestrial biological diversity. During the last ten years significant progress has been to conserve areas for marine biodiversity. As optimists we have to believe that we can continue to increase the amount of land set aside for as nature reserves. How much of what we have learned from studying terrestrial systems will apply to marine (and freshwater) systems? Here, I review some of the techniques for nature reserve design that have focused on specific species, communities or human uses. I will then discuss the degree to which the major innovations in terrestrial reserve design theory (e.g., SLOSS, corridors, edge effects) apply to the design of marine reserves - particularly those designed to conserve migratory marine mammals.

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#### PROMOTING BIODIVERSITY CONSERVATION IN BOLIVIA THROUGH COMMUNICATION AND COLLABORATION.

To address the challenge of promoting broad participation in biodiversity conservation, the Museum's Center for Biodiversity and Conservation (CBC) has initiated nonformal education and training efforts in association with its international field projects. This poster presents a process of bringing together community and scientific expertise to enable effective local and regional planning and sustainable resource management. Begun in 1998, Conservation of Biodiversity through Integrated Management is a collaboration in Bolivia that includes the CBC, the Museo Nacional de Historia Natural, and the Museo de Historia Natural Noel Kempff Mercado. Along with interdisciplinary research and professional development, the program catalyzes interactions among stakeholders in selected protected areas. Training workshops for community representatives and park staff have been instrumental in building relationships among partners, legitimizing interpretation as a component of conservation projects, and increasing participants' capacity to effectively communicate and interpret environmental information. Local partners—museum educators in particular—are taking on a progressively greater role in facilitating training and follow-up with workshop participants. Small grants offer an opportunity for participants to apply what they have learned in community-based conservation and development projects. Project partners will continue to build on these efforts to support effective management and interpretive strategies in Bolivia's protected areas.

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#### ISLAND ENDEMISM AND EXTINCTIONS IN NORTHWESTERN MEXICO.

To guide conservation action, we developed a database of the biodiversity and threats to the islands of Northwestern Mexico. There are >250 islands in the region with a total area of ~5,277 km<sup>2</sup>. These islands are diverse in vertebrates and have high levels of endemism at the species and subspecies levels: ~141 land mammals (75% endemic), ~179 reptiles and amphibians (43% endemic), and at least 48 endemic birds. There have been 23 possible extinctions of endemic vertebrate species and subspecies. Of these, 21 were likely caused by introduced mammals (primarily feral cats), one was caused by over-hunting, and one by natural environmental stochasticity. Possible extinctions were not evenly distributed across taxa. Approximately, 12% of endemic mammals, ~20% of endemic birds, and 0% of endemic reptiles and amphibians may be extinct. Prior to 1995, introduced mammals were present on  $\geq$ 49 islands in the region. The Island Conservation & Ecology Group, National Autonomous University of Mexico, Center for Biological Investigations, and the National Protected Areas Department have completed 28 mammal removals from 19 of these islands.

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#### MONITORING THE DISTRIBUTION AND IMPACTS OF ALIEN WEEDS TO FACILITATE RECOVERY OF A DRY, SUBALPINE HAWAIIAN FOREST.

Alien plants have greatly impacted native ecosystems in Hawai'i, especially in the lowlands where most plant communities are dominated by introduced species. High elevation areas (above 2000m) are believed to be impacted less. However, many aliens originating from temperate and Mediterranean regions have become widely established at high elevations, and others with very local distributions have the potential to spread more widely. On Mauna Kea alien plants have drastically changed the natural fire regime, reduced regeneration of native species, and have potentially provided additional resources for alien insect pests. In this paper, we describe the distribution of a number of alien plants that are currently a threat, or pose a threat, to the subalpine forests of Mauna Kea and discuss their implications to this unique environment and the palila (*Loxioides bailleui*), an endangered songbird restricted to this habitat. We recommend continuing to monitor alien plants on Mauna Kea because, 1) it is often difficult to predict what species will eventually spread and become a problem, and 2) the plant community is very dynamic as the forest recovers from > 150 years of ungulate damage making it difficult to predict the outcomes of interactions between native and alien plants.

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#### PREDICTING THE SUCCESS OF INVADING SPECIES: APPLYING STOCHASTIC MODELS OF POPULATION GROWTH AND THE ROLE OF ALLEE EFFECTS.

Because they are often very small, inoculating propagules of invading species are subject to the caprice of two sources of stochasticity: demographic and environmental. These stochastic factors supply a condition under which some inoculating populations will subsist while others fail. The development of stochastic models in ecology in general, and population viability analyses (PVA) in particular, presents a formalized probabilistic approach for studying invasions of exotic plants and animals. Here we present results from a two-pronged exploratory investigation for the Great Lakes invasive zooplankter *Bythotrephes longimanus*. First, we use time series data to estimate population growth parameters and predict invasiveness. Second, using life history data available in the literature, we simulate possible population trajectories to estimate the probability of invasion and corroborate the analytic result. Results suggest that Allee effects and quasi-Allee effects have significant consequences for the growth of introduced populations, possibly accounting for often observed "lag-times" during the initial stages of population establishment. Where Allee effects are not present, as few as 10 introduced individuals results in a high (>.5) probability of invasion. This result is achieved independently through both simulation and analytical techniques.

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#### EXTINCTION IN A FIELD OF BULLETS: INTRINSIC VS. EXTRINSIC CAUSES IN THE DECLINE OF THE WORLD'S FRESHWATER FISHES.

Because human actions alter aquatic ecosystems similarly worldwide, the extinction risk among many freshwater fishes that share particular life-history traits may also be similar. Determining whether taxonomic selectivity exists among the world's freshwater fish families is then a key step in predicting future species declines and triaging conservation efforts. We use binomial statistics to look for taxonomic patterns among the world's freshwater fish families. Families are identified as being at risk of extinction if at least one species within a family is classified as either extinct or at risk of extinction by the IUCN Redlist of Threatened Animals. Eighteen freshwater families have more threatened species than expected if extinction risk was evenly distributed across all families. Next, we use a series of chi-squared analyses to determine if known family-level characteristics produce this taxonomic pattern. We find that families inhabiting well-studied regions of the world contain more threatened species. However, we find no indication of a unifying set of extinction-promoting biological or ecological traits that contribute to extinction risk among freshwater families. A possible explanation for this discrepancy is that aquatic alterations worldwide are so severe that extinction is driven by extrinsic rather than intrinsic factors.

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#### ISLANDS OF COLD WATER IN THE DESERT: DEFINING HABITAT FRAGMENTATION, ITS EFFECTS, AND WHAT TO DO ABOUT IT.

To understand the effects of habitat fragmentation, it is essential to identify the causes of fragmentation, and to define habitat structure and its effects. In many systems, such as oceanic islands or lakes, the structure of habitat may be obvious. In others, fragmentation of habitat may be less apparent. We developed models to predict the effects of both local and geographic environmental gradients on the distribution of threatened cutthroat trout in the Great Basin, USA. These models were linked to a geographic information system to create watershed "patches" of suitable habitat. This model was used to predict occurrence of cutthroat trout at two scales: among patches, and among patch networks within a large (70,000 km<sup>2</sup>) basin. This information forms the template for a spatially explicit landscape classification to identify specific threats (habitat loss and nonnative species) and alternative conservation management strategies (habitat restoration, control of nonnative species, reintroductions). Our approach to addressing the problem of habitat fragmentation should be generally relevant for imperiled species with widespread distributions and restricted habitat requirements.

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#### WITHIN POPULATION GENETIC STRUCTURE IN GOLDEN CHANTERELLES ASSESSED WITH MICROSATELLITE LOCI.

The Northwest Forest Plan has drawn attention to conservation needs for many species of fungi including the commercially harvested golden chanterelle (*Cantharellus formosus*). Cryptic growth habits make fungal individuals difficult to observe and life history information critical for management efforts is lacking. In broadly distributed species like *C. formosus*, knowledge of within-population genetic structure is a prerequisite for planning larger scale studies upon which management decisions are based and contributes to our understanding of life history parameters difficult to measure without genetic data. Fruit bodies from 167 *C. formosus* individuals were mapped and collected from a 50 year old, 50 ha stand of naturally regenerated douglas fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*). Sixty-five unique genotypes resulted from scoring these collections at four microsatellite loci. The spatial distribution of the 10 most frequent alleles was studied using Moran's I statistic. Significant but weak spatial autocorrelation was detected in the four smallest distance classes estimating a 250-400 m patch size for *C. formosus*. This result indicates that either limited spore dispersal possibly coupled with inbreeding, long lived individuals fragmented over large areas, or some interaction between these processes works to maintain fine scale genetic structure in this species.

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## GEOGRAPHIC RANGE AND HABITAT OF RARE MOLLUSKS IN NORTHERN CALIFORNIA.

Under the Northwest Forest Plan, national forests are mandated to survey for a variety of “Survey and Manage” species prior to on-the-ground activities. Almost no quantitative data exists for the majority of the 400+ “Survey and Manage” species. We sampled at 308 randomly-selected points within a 5.4 km grid network (n = 1055 points) over 23,000 km<sup>2</sup> in northern California. We detected 93 species or subspecies of mollusks and we estimated geographic ranges (extent of occurrence) and habitat associations of 9 terrestrial “Survey and Manage” mollusks. We also evaluated whether these species occurred disproportionately in reserves that were developed for northern spotted owls. In addition to discovering several new mollusk species, we found that the 9 selected “Survey and Manage” mollusks were as likely to be detected on reserved lands as lands where timber harvesting is allowed. We developed areas of occupancy models for each species using spatial data in conjunction with vegetation data from several scales. Geographic ranges that were produced by connecting the outermost locations for each species were smaller than those generated by including locations that were not sampled but which had high predicted probabilities of occurrence. A relatively small region of the study area accounted for most of the diversity of mollusks.

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## ASSESSMENT OF AVIAN NON-TARGET HAZARDS FROM THE BROADCAST OF RODENTICIDE BAIT IN HAWAIIAN FORESTS.

The presentation will summarize the results of a field study designed to assess the relative risk that the broadcast application of rodenticide bait poses to Hawaiian forest bird communities. This study was conducted in four different forest habitats in Hawai'i using two different formulations of placebo bait. Non-target risk assessment has two components: bait acceptance and toxicity (if bait is consumed). This project was designed to assess the former issue, bait acceptance. Risk was assessed by comparing placebo bait uptake to the relative abundance of specific avian species within a particular avian community. Vertebrate uptake of placebo bait was monitored in each site using forty infrared monitors and cameras. With data from three of eight replicates analyzed (approx. 7,600 slides of vertebrate bait consumption) only eighty-five slides from one site documented bait consumption by a single avian species [the introduced red-billed leiothrix (*Leiothrix lutea*)]. Rats were documented consuming bait 7,500 times. This data suggests that there is a relatively low direct risk to Hawaiian forest birds from the broadcast of pelletized rodenticides and will be used to support multi-agency efforts to obtain regulatory approval of the aerial broadcast application of rodenticide bait for conservation purposes in the state of Hawai'i.

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## FERAL CAT (*FELIS CATTUS*) PREDATION ON LOW ELEVATION NATIVE SEABIRD COLONIES ON MAUI ISLAND.

Feral house cats, introduced to many areas of the world, have been implicated in many cases of predation on native mammalian and avian wildlife, often leading to extinctions of unique island species. Native seabirds, such as the common Wedge-tailed Shearwater (*Puffinus pacificus*) and more rare Bulwer's Petrel (*Bulweria bulweri*), which nest in coastal colonies at low elevations on Maui were negatively impacted by predation by feral cats. Cat predation on the seabirds was investigated at several locations on the main island of Maui to determine overall predation scope and predation efficiency, to characterize temporal patterns to predation, and to provide an assessment key for identifying cats as predators. Peaks in predation at colonies of sufficient size were found to be diphasic, and tied to the bird's biology. Small colonies were vulnerable to total failure and larger colonies to losses of returning adults and late-stage chicks and adults. Comparison of cat free Molokini islet illustrated cat predation has a sustained negative impact on established Maui native seabird colonies, expansion of colonies, and colonization of new areas by native seabirds.

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## MateR<sub>x</sub>: A PRESCRIPTION FOR GENETIC MANAGEMENT OF CAPTIVE POPULATIONS.

Genetic management of captive populations can increase long-term population viability and fulfills goals to maintain genetic diversity of founding populations. Rigorous genetic analyses of populations guide decisions selecting specific animals to breed and pair with each other. We present a software model, MateR<sub>x</sub> designed to standardize and simplify

selection of genetically appropriate pairs. Four genetic factors are evaluated in the pairing process: change in gene diversity, inbreeding coefficient for prospective offspring, parity of parental mean kinships and degree of unknown pedigree information. Currently, specially trained advisors interpret and synthesize these parameters to make their genetic decisions. MateR<sub>x</sub> quantifies each of the four factors based on a combination of genetic theory and current management practices and in a second step, integrates them into a single Mate Suitability Index (MSI). The MSI identifies pairs as beneficial or detrimental to the population's genetic health. Okapi and cinereous vulture, populations with different genetic structures, are compared and contrasted using MSI. MateR<sub>x</sub> standardizes genetic management because parameter scores are applied consistently across species and repeatable over time.

EASON, CHARLES T., Eric B. Spurr, and Elaine C. Murphy. CENTOX (Centre for Environmental Toxicology), Landcare Research, P.O. Box 69, Lincoln 8152, New Zealand (ECT, EBS), and Department of Conservation, Private Bag 4715, Christchurch, New Zealand (ECM).

#### BIOACCUMULATION RISKS ASSOCIATED WITH BRODIFACOU M *VERSUS* OTHER ANTICOAGULANTS: OPTIONS FOR RODENT CONTROL.

Aerial application of cereal baits containing brodifacoum has been used successfully for eradication of rats on islands around New Zealand. Brodifacoum has also found increasing favour for rodent and possum control on the mainland of New Zealand. Concurrent with the increased field use of brodifacoum, concerns have increased with regard to primary and secondary poisoning and contamination of wildlife. Brodifacoum has been detected in significant numbers of pigs, deer, cats, stoats, and bird life from these areas. In view of the potential impact on pig hunters and dogs consuming wild pig meat and offal and, to a lesser extent, deer, the wide-scale field use of brodifacoum baits on mainland New Zealand is under review. The comparative toxicokinetics of alternative less persistent toxicants such as coumatetralyl, diphacinone and warfarin is being re-evaluated in rats and compared with brodifacoum, and their tendency to bioaccumulate is being reassessed as part of a selection process prior to field use. Use patterns of anticoagulants on small to medium sized islands (for eradication) and on mainland areas varies and the pros and cons of different anticoagulants for different uses will be presented.

ECKERT, KATHERINE A., Nina E. Hahn, Michael D. Stuart, and Hal Markowitz. Dept. of Biology, San Francisco State University, HH 520, 1600 Holloway Ave. San Francisco, CA 94132-1722, USA (KAE and HM), Office of Laboratory Animal Care, University of California at Berkeley, NW Animal Facility Rm. 203, Berkeley, CA 94720-7150, USA (NEH), Dept. of Biology, University of North Carolina, Asheville, NC 28804, USA (MDS).

#### THE UTILITY OF PARASITE DATA FOR THE CONSERVATION OF BLACK HOWLER MONKEYS IN BELIZE.

The implications of specific parasite infection may be important in discerning ecological, behavioral and evolutionary trends in the host-parasite relationships for a species. For non-human primate populations, there is an added impetus to understand their parasitic relationships due to the fact that they are susceptible to many human pathogens, and may be particularly sensitive to human encroachment on their habitat. Since little published information currently exists on the presence and taxa of parasites of black howler monkeys (*Alouatta pigra*), a coprological survey was performed of *A. pigra* living in the 385 ha. Lamanai Archaeological Reserve, in Belize. Fecal samples (n=269) were analyzed from monkeys living throughout the Reserve, including some areas adjoining tourist destinations and human settlements. The formalin-ethyl-acetate sedimentation procedure was used for each sample to create six wet mounts that were scanned systematically. Over forty percent (40%) of the individuals in the sample population were found to have parasitic infections, the majority of which were of a trematode believed to be in the family *Dicrocoelidae*. Future comparisons can be made with these baseline data to help thoroughly assess impacts of anthropogenic disturbance, natural disasters or other stresses to this population.

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#### CENSUSING ELUSIVE ANIMALS: THE FOREST ELEPHANTS OF KAKUM NATIONAL PARK, GHANA.

One quarter to one third of the remaining African elephants belong to the forest subspecies (*Loxodonta africana cyclotis*). These animals are difficult to observe in the dense rainforests, and previous studies have relied on indirect methods to estimate population sizes. Using multilocus genotyping of non-invasively collected samples, we performed a genetic census of the forest elephant population at Kakum National Park, Ghana. We estimated population size, sex ratio and genetic variability from our data, then combined this information with field observations to divide the population into age groups. Our population size estimate of 225 (confidence interval 173 to 308) was very close to that obtained using dung counts, the most commonly used indirect method of censusing forest elephant populations.

For forest elephant populations to persist as their habitat is fragmented by expanding human populations, management will be increasingly important. Our genetic census provides data that will allow managers to plan for the conservation of what may prove to be the largest population of forest elephants in west Africa.

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EXPLORING THE SENSITIVITY OF AN ENDANGERED SPECIES TO CHANGES IN DEMOGRAPHY AND HABITAT USING AN INDIVIDUAL-BASED MODEL FOR THE CAPE SABLE SEASIDE SPARROW (*AMMODRAMUS MARITIMUS MIRABILIS*).

The Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), a US endangered species, occurs in the isolated short-hydroperiod marl prairies of the Everglades of South Florida. Several sub-populations are threatened by changes in hydrology and subsequent habitat change. In order to explore the effects of a changing landscape on sparrow population dynamics, we constructed a spatially-explicit individual-based Monte Carlo model. The model (SIMSPAR) includes the topography, vegetation and hydrology of sparrow habitat as well as field-derived demographic parameters. We explored the population's sensitivity to behavioral, demographic and landscape level changes. Sparrow populations are highly sensitive to changes in maximum number of clutches, mortality rates, and female dispersal distance. Degradation of sparrow habitat resulted in a greater than proportional decrease in breeding population size and increased the population's coefficient of variation. If habitat was degraded by allowing shrub invasion of higher elevation breeding areas, the population levels declined to a greater extent than if habitat was degraded by other means. Although this population is sensitive to changes in demographic and behavioral parameters, these results highlight the sparrow's sensitivity to habitat quality and the importance of using spatially explicit models to explore a species response to landscape level as well as demographic changes.

ELPHICK, CHRIS S., J. Michael Reed, and J. Marcelo Bonta. Department of Ecology and Evolutionary Biology, University of Connecticut, 75 North Eagleville Road U-43, Storrs, CT 06269, USA (CSE), Department of Biology, Tufts University, Medford, MA 02155, USA (JMR), and 150 Oswego Summit, Lake Oswego, OR 97035, USA (JMB).  
CORRELATES OF POPULATION RECOVERY GOALS IN ENDANGERED BIRDS.

Endangered species recovery plans commonly set population size goals that are used to define the success of recovery efforts. We examined variation in these goals for bird species listed under the United States Endangered Species Act to determine whether there were simple predictors of recovery population size. The median population sizes that must be met for a species to be removed from the list or down-listed to the threatened category are 4,000 and 1,500 respectively, but there was much variation. Most variation in population recovery goals (? 75%) was explained by the population's size when the recovery plan was written. Species listed when their population's size was relatively large have higher population recovery goals, whereas those listed when populations were small have lower population goals. Population sizes set for recovery also increased over time and were higher for species listed throughout the United States. In combination, these three variables explained 86% of the variance in de-listing population goals and 94% of the variance in down-listing goals. Body mass, annual fecundity, maximum life-span, whether the population was listed as threatened or endangered, and whether a population viability analysis was conducted were not significantly associated with population recovery goals.

ERASMUS, BAREND F.N., Albert S. van Jaarsveld, Steven L. Chown, Mrigesh Kshatriya, and Konrad J. Wessels. Conservation Planning Unit, Department of Zoology & Entomology, University of Pretoria, Pretoria 0002, South Africa (EBFN), Centre for Environmental Studies, University of Pretoria, Pretoria 0002, South Africa (AsvJ), Department of Zoology & Entomology, University of Pretoria, Pretoria 0002, South Africa (AsvJ, SLC), Conservation Planning Unit, Department of Zoology & Entomology, University of Pretoria, Pretoria 0002, South Africa (MK), Institute for Soil, Climate & Water, Agricultural Research Council, Private Bag X79, Pretoria 0001, South Africa (KJW).

A BROAD SCALE ASSESSMENT OF SPECIES' DISTRIBUTION RESPONSES TO CLIMATE CHANGE.

We explore the spatial response of the distribution of selected species to climate change using a climate envelope model. The model can interpolate the distribution of poorly-sampled taxa as well as predict responses to a changing climate. Species from the arid western parts of South Africa are expected to experience range contraction and an eastward range shift to the possible detriment of resident eastern species. Shifted ranges may conflict with current land use practices that are unsuitable to sustain viable populations. Given an already fragmented habitat matrix within which these range changes are expected to happen, the ability of species to change their ranges as a successful response to climate change is called into question. Such a scenario will lead to climate sensitive species being limited

to shrinking islands of suitable habitat. Given the expected extent of the spatial response, conservation planners can no longer afford to ignore the effects of climate change when engaged in long-term planning.

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#### ROADS AND TOADS: AMPHIBIAN MORTALITY IN RELATION TO RAINFALL, ROADWAY SURFACE MOISTURE, AND TRAFFIC VOLUME.

Roads constitute a direct and often permanent loss of wildlife habitat, can serve as physical or psychological barriers to animal movements, and are often the source of exceedingly high levels of animal mortality. Our goal was to better understand the effects of roads on amphibian populations in a planned landscape corridor in southern California. Road cruising was employed to examine the usage of roadways and related mortality levels of amphibians. Two hundred and fifty four evening road cruising surveys were conducted between February and April, 1999 and 2000. During 93 road nights with 'wet roads', we recorded 465 dead animals and 505 live animals on roadways, yielding an overall mortality rate of 48%. In contrast, during 161 road nights that were classified as having 'dry roads', we recorded only 25 dead animals and 105 live animals, yielding an overall mortality rate of 19%. In addition to rainfall, road mortality was also influenced by the type of road surveyed; as expected, highest mortality rates occurred on highly traveled roads, with small two-lane roads exhibiting the lowest mortality rates. Our result suggest that roadways in the region are negatively impacting herpetofauna populations, particularly when roads are wet in areas of high traffic volume.

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CREATED VS. NATURAL COASTAL ISLANDS: DEGRADING HABITATS, ATLANTIC WATERBIRDS, AND MANAGEMENT NEEDS.

In the mid Atlantic region of the U.S., breeding colonial waterbirds such as gulls, terns, Brown Pelicans (*Pelecanus occidentalis*) and Black Skimmers (*Rynchops niger*) nest on barrier islands, created dredged material islands, and to a lesser extent natural marsh/ shell pile islands. We compare breeding distribution and population changes of selected species in New Jersey, Virginia, and North Carolina from the 1970s to the 1990s. In New Jersey and North Carolina, species of concern such as Common Tern (*Sterna hirundo*), Black Skimmers and Gull-billed Terns (*S. nilotica*) that depended heavily upon dredged material islands in the 1970s have experienced declines in populations in the 1990s, with a simultaneous decline in quality (and use) of dredged material islands. Rather than maintaining high quality sandy dredge sites, managers are diverting to "beach nourishment" projects instead. In Virginia, few dredge material islands are found, however, here populations of terns and skimmers on barrier islands are declining during the past 25 years and marsh and artificial sites are becoming more important; predators (fox, raccoon, coyote) have increased on barrier islands. A strong plea is made for coastal managers to better maintain or create additional small dredge, shell, or artificial islands as larger barrier islands become increasingly degraded by human activities or mammalian predators.

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#### FARMING FOR SHOREBIRDS: USING STABLE ISOTOPES TO QUANTIFY THE VALUE OF AGRICULTURAL LAND FOR WINTERING DUNLIN.

The Fraser River Delta represents the only major over-wintering habitat in Canada for shorebirds. However, the relative dietary importance of farmland to shorebird populations was not previously established, and has been determined in this study by means of stable isotope analysis. Comparing blood and tissue samples from Dunlin (*Calidris alpina*) with those of terrestrial-exclusive American Robins, (*Turdus migratorius*) and marine-exclusive White-winged Scoters, (*Melanitta perspicillata*), analysis of Carbon-13 and Nitrogen-15 indicates considerable variation between individuals in the relative contribution of terrestrial prey to overall diet. Individual values range from highly marine signatures to highly terrestrial ones, but a 3-year population average ( $\delta^{13}\text{C} = -17.55 \text{‰} \pm 2.6$ ) suggests that use of fields is widespread throughout the population. High variance in isotopic values suggests that field feeding is a widely adopted strategy amongst wintering Dunlin rather than a habit adopted by a small subset of the population. Isotopic values were significantly different between years ( $F^2 = 30.19$ ,  $df = 2$ ,  $p < 0.0001$ ). Stable isotope values also indicate a mid-winter peak in field feeding. Land use changes in the Fraser Delta are reducing the

availability of farmland to wildlife. This research highlights previously undervalued agricultural habitat as a conservation concern.

EWEL, KATHERINE C., Kimberly Bonine, Stacy M. Rowe, Moses Palik, and Erick E. Waguk. USDA Forest Service, 1151 Punchbowl St., Rm. 323, Honolulu HI 96813, USA (KCE), Institute for International Studies, Stanford University, Stanford CA 94305-6055, USA (KB), Ngatpang State Government, Republic of Palau 96940 (SMR), and Kosrae Island Resource Management Program, PO Box DRC, Kosrae, FSM 96944 (MP, EEW).

#### MANGROVE CRAB (*SCYLLA* SPP.) HABITAT IN THE CAROLINE ISLANDS.

The mangrove crab *Scylla* spp., also called mud crab, is commonly harvested for consumption throughout the tropical Indo-Pacific. Decreased trapping success and increased mangrove tree harvesting rates in some places have raised questions about specific habitat requirements and the need for management. We established transects through mangrove forests in both the Republic of Palau and the State of Kosrae, Federated States of Micronesia, in order to determine basic characteristics of crab burrow location. Crab burrows were found in riverine and interior mangrove forests, with no affinity for particular species of trees. Burrow density was much higher in Palau (1.63/100m<sup>2</sup>), where sampling was concentrated primarily in riverine mangrove forest, than in Kosrae (0.20/100m<sup>2</sup>), where sampling was dispersed in and around fringe, interior, and riverine forests. Burrow density was correlated with presence of logs and, particularly in interior stands, with presence of forest gaps. In Kosrae, it was also correlated with the width of the stand, i.e., distance from land to shore. Mangrove crabs appear to be habitat generalists. Their abundance is not likely to be diminished by gaps resulting from natural tree mortality and firewood harvesting. Instead, burrow habitat appears to be enhanced by logs on the forest floor.

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#### LINKING SPATIAL RARITY AND EXTINCTION DYNAMICS: ACROSS-SCALE STUDIES OF DESERT FISHES.

Extinction is one of the most fundamental processes in ecology. It shapes evolution, community structure, and patterns of biodiversity. Yet studies of extinction are scarce. We have taken advantage of an extraordinary database concerning occurrence records for native fishes in the southwestern US and northwestern Mexico to investigate relationships between extirpation and patterns of rarity and life-history traits. This unique database includes over 25,000 locality records spanning 160 years of field research for all 50 known taxa of fishes from the Sonoran Desert region. Key to our project is the development of new methods for quantifying patterns of rarity that are independent of the spatial scale of analyses. We discuss how the patterns of spatial rarity these fish exhibit relate to their extinction dynamics (e.g., frequency and pattern of extirpation events) and current levels of endangerment. We also suggest ways in which patterns of rarity and extinction can be predicted by life-history attributes.

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#### COMPARING BEHAVIOR OF HAND-REARED OF PARENT-REARED SHRIKES, IMPLICATIONS FOR RELEASE.

A captive breeding population of the endangered San Clemente loggerhead shrike (*Lanius ludovicianus mearnsi*) was established in 1991. Chicks are produced both by pulling clutches for artificial incubation and hand-rearing, and by allowing the shrikes to raise their own chicks. Behavioral observations of foraging and flight skills of juvenile release candidates and parental care behavior of the captive flock have been conducted for both parent- and hand-reared birds. Timed samples of juvenile release candidates showed that parent-reared birds were more wary than hand-reared; they spent significantly less time in "dangerous" areas (i.e., on low perches or on the ground). Observations of captive breeding pairs revealed that parent-reared adults were more wary as parents. Once the chicks hatched, parent-reared adults had significantly higher rates of alarm calling than did the hand-reared adults. Once young shrikes fledge, parent shrikes actively sing in close proximity to the chicks, and young birds learn their parents' songs. Parent-reared adults sang significantly more during pair introductions. Thus parent-reared birds learn song repertoires in a social setting, they subsequently used song at higher rates than did hand-reared shrikes. Thus parent-reared shrikes may be better release candidates both because of higher anti-predator vigilance and improved song learning.

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## USING STAGE-BASED DEMOGRAPHIC MODELS TO GUIDE CAPTIVE MANAGEMENT: WESTERN LOWLAND GORILLAS.

Captive population management integrates genetics and demography to guide populations towards sustainability and stability. Age-based demographic models currently predict population trajectories and future space needs. However, stage-based or system models may be more appropriate because of their flexibility in representing complex dynamics, when vital rates are determined less by age than by non-demographic factors such as social or developmental state, husbandry or health issues, or the logistics of multi-institutional management. Western lowland gorillas (*Gorilla gorilla gorilla*) in North American zoos are currently managed via age-based matrix models. Yet stage models are appropriate because gorillas exhibit clear stages (infants, silverbacks, reproductive females, post-reproductives), are polygynous with bachelor groups of non-breeding males, and have other social, logistic, and husbandry concerns that provide complex structure to management plans. Of particular interest are the demographic and genetic effects of breeding and bachelor group structure. The gorilla population has exhibited significant bias in birth sex ratio, creating concern about population viability and management implications. We present a stage model that confirms impending management, but not demographic, problems under a variety of sex ratio biases. This model will assist decision-making about future birth rates and space needs for breeding and non-breeding groups.

FAY, KERRI, Katie Cassel, David Alexander, Ellen Coulombe, Laura Arnold, and Kay Koike. Koke'e Resource Conservation Program, Koke'e Museum, P.O. Box 100, Kekaha, HI 96752, USA.  
CONSERVING KAUAI'S RESOURCES.

The Koke'e Resource Conservation Program (KRCP) is a volunteer based alien species control program sponsored by the non-profit Hui o Laka/Koke'e Museum in collaboration with the Hawai'i Department of Land & Natural Resources (DLNR), State Parks Division. KRCP involves the public in protecting native ecosystem resources. Objectives are: 1) Conduct invasive plant removal in selected areas on Kauai, particularly those that still have relatively intact native forest. 2) Eliminate priority incipient weeds before they become widespread. KRCP is involved in eradication of *Miconia calvescens*, which was recently re-discovered in Wailua State Park. 3) KRCP has also taken action in the vicinity of endangered plants: weeding, rat baiting and fencing, which has resulted in survival of seedlings of the endangered *Kokia kauaiensis* in Kalalau Valley and *Pteralyxia kauaiensis*, and renewed growth on *Solanum sandwicense* that had been over-run by *Rubus*. Over the past three years staff and volunteers weeded 870 acres with 21,581 volunteer hours, have found new locations of several endangered species and discovered many more intact, botanically rich areas of forest that need protection now. Funded by the Hawai'i Community Foundation, the U.S. Fish & Wildlife Service, the U.S. Forest Service, and private donations.

Feldheim, Kevin A., Samuel H. Gruber, and MARY V. ASHLEY. Department of Biological Sciences (M/C 066), University of Illinois at Chicago, 845 W. Taylor St., Chicago, IL 60607, USA (KAF, MVA), Division of Marine Biology and Fisheries, Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, FL 33149, USA (SHG).

## STOCK STRUCTURE AND THE ROLE OF THE NURSERY IN LEMON SHARK RECRUITMENT.

Little information is available on breeding patterns, demographics or population genetic structure of most elasmobranchs, but such information is clearly needed to develop appropriate management plans. Here we characterize the local recruitment dynamics of the lemon shark (*Negaprion brevirostris*) and population genetic structure at greater spatial scales. DNA microsatellites developed for lemon shark were used to characterize relatedness among cohorts of juveniles at three nursery lagoons in the western Atlantic. Significant differences in reproductive dynamics were found among nurseries as indicated by levels of relatedness among juveniles, annual growth rates, and recapture rates. Lemon shark samples from the northern and southern parts of the range of the species in the western Atlantic were used to characterize gene flow patterns. Estimates of genetic structure yielded small but significant values. No sharp discontinuities were found between Caribbean and Brazilian waters, indicating that gene flow occurs throughout the western Atlantic with no evidence for distinct stocks.

Felling, Candace, Sherri Hiraoka, Teresa Restom, Jennifer Rodwell, ELIZABETH STAMPE, Georgina Lillich, Shari Lyons, Sean Mark, Scott Murakami, Frank Parrish, Shana Brickman, Kim Moffie, Gustav Bodner, Jennifer Garrison, David Hopper, Anita May, and Rebecca Rundell. Botany Department (CF, SH, TR, JR, ES), Geography Department (GL, SL, SM, SM, FP), Hawai'i Institute of Marine Biology (SB), Law School (KM) and Zoology Department (GB, JG, DH, AM, RR), University of Hawai'i at Mānoa, Honolulu, HI 96822, USA.

## A SYSTEMS-BASED EVALUATION OF FOREST BIRD CONSERVATION EFFORTS IN HAWAII.

Although tremendous amounts of funds, research, time and energy have gone into the preservation of Hawai'i's forest birds, the birds are still declining. What aspects of the system of forest bird conservation in Hawai'i are not working? As the culmination of a graduate seminar, we examined the roles of management institutions, the public, and scientists, and the interaction among these groups. Our resources included interviews, literature and Internet research, case studies, and an analysis of newspaper coverage. We found that considerable scientific understanding of the problem already exists; however, several factors still hinder progress. These include a lack of public awareness and of consistent, long-term funding, a lack of institutional flexibility, and a lack of trust among stakeholders. Successful public outreach could incorporate a sense of pride of place and community involvement in conservation efforts. Increased public awareness would in turn bolster funding. Institutional communication and evaluation are improving, but more follow-up is needed. More communication is also necessary across groups, among stakeholders with different goals. We provide specific recommendations to make the system of bird conservation in Hawai'i more effective. Our analysis is not limited to Hawaiian bird conservation; any conservation effort can be approached from this systems perspective.

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#### LOW GENETIC VARIATION REDUCES PLANT FITNESS IN POPULATIONS OF A NARROW ENDEMIC PLANT.

The sporophytically self-incompatible *Cochlearia bavarica* is known from <30 localities in Bavaria, SE Germany, where it occurs in isolated populations with up to 5000 flowering plants. Larger populations have a higher isozyme variability than smaller populations. After free pollination, compatibility and the cumulative fitness during 14 months in a common garden were larger for plants from larger field populations. Compared with free pollination, hand pollination (with self pollen or pollen of one donor) resulted in reduced compatibility and offspring fitness. This suggests, that several pollen donors contribute to free pollination. Positive effects of free pollination compared with hand pollination on compatibility and cumulative offspring fitness were smaller for plants representing smaller populations, which suggests increased relatedness of mates in small populations. Compared with hand-outcrossing, hand-selfing resulted in reduced compatibility and reduced offspring fitness. Our study demonstrates twofold fitness reductions for smaller populations of *C. bavarica* (i.e. Allee effects) associated with their reduced genetic variability: reduced cross-compatibility and reduced offspring fitness.

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#### THE SILENT INVASION: PARASITES OF EXOTIC AQUATIC SPECIES IN SOUTHERN CALIFORNIA.

Exotic species are known to be the cause of declines in many species, with islands and freshwater aquatic systems showing the greatest impacts. Southern California is now the home of scores of exotic aquatic species ranging from copepods to beavers, and much of the native diversity of these systems is either extinct or declining. Surprisingly little is known of the parasitology of the aquatic organisms in southern California in general, and what exotic parasites may be associated with the exotic species. We analyzed the parasite communities of two exotic frogs and several exotic and native fish across different aquatic habitats. We found many exotic parasites associated with the exotic species, and that some had moved to native hosts. In particular, the African clawed frog was maintaining about 30% of its endemic parasite fauna in California, and fish parasites common to the aquarium trade were now occurring in natural habitats. Parasite transmission appeared tied to similar habits between native and exotic species thus putting some species at greater risk of invasion. Management and conservation implications of this study are that the removal of the exotic species is only one step and needs to be followed by intensive parasite analyses.

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#### SPECIES-SPECIFIC EDGE EFFECTS ON NEST SUCCESS AND BREEDING BIRD DENSITY IN A FORESTED LANDSCAPE.

Using natural nests of eight bird species, we provide one of the first multi-species tests for edge effects on reproductive success in a forested landscape. Our primary objective was to assess whether distance to the edge of recent clearcuts was related to nesting success in intact northern hardwood forests. Estimated nest success was generally lower for the two ground-nesting species than for the six canopy nesting species. Brood parasitism was < 3 % for species which

typically accept eggs of the Brown-headed Cowbird (*Molothrus ater*), and nest predation was the most common cause of nest failure. Probability of nest failure was influenced by distance to forest edge for the ground-nesting Hermit Thrush (*Catharus guttatus*) and Ovenbird (*Seiurus aurocapillus*), but not for six canopy-nesting species. Our data suggest that the effect of proximity to edge on nest success for ground-nesting species may penetrate 300 m into intact forest while the effect of proximity to edge on nest density may penetrate farther. Because areas of contiguous forest (e.g., publicly owned forest) in the Upper Great Lakes remain relatively intact, they may serve as source habitat for regional songbird metapopulations.

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#### EMPIRICAL VALIDATION OF A NEW METHOD FOR UMBRELLA SPECIES SELECTION.

Empirical validation that putative umbrella species protect many co-occurring species is rare. Using data from two taxa and three ecoregions, we tested the effectiveness of a recently-developed index for selection of umbrella species. We also tested whether species identified with the index were more effective umbrellas than species selected at random, whether sample size and intensity affect selection of umbrellas, and whether the index could identify cross-taxonomic umbrellas. The most realistic scenario, conservation of subsets of locations with relatively high numbers of umbrella species, generally would protect = 0.75 of each assemblage. Randomly selected sets of species often required that more locations be designated for protection than did sets selected using the umbrella index. The umbrella index tended to identify fewer locations that offered an equivalent level of species protection. Sampling intensity affected which species were identified as umbrellas, but not the proportion of species that would be protected. Umbrella species were no more effective than randomly selected species for cross-taxonomic applications; nonetheless, neither group was significantly less effective than same-taxon umbrellas. It may indeed be feasible to identify effective umbrella species, but our studies do not support unconditional utility of the umbrella index or umbrella species concept.

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NEW USES FOR THE DEAD: RECONSTRUCTING BASELINE CONDITIONS ON THE COLORADO DELTA. Paleocological and geochemical techniques can be used to reconstruct the species composition, abundance, and environmental tolerances of marine shelly invertebrates prior to human alteration of the environment. The problem on the Colorado Delta, like so many other places, is that people didn't start making scientific observations until people had already modified the habitat. We estimated benthic shelly productivity before the upstream water diversions that began in the 1930s. We used field counts, satellite images, radiocarbon-dated shells and analyses of shell growth to estimate pre-diversion population densities of ~50 clams/m<sup>2</sup>. Surveys of the living shelly fauna indicate densities of only 3 clams/m<sup>2</sup>. The oxygen isotope composition of prehistoric shells of the bivalve mollusk *Mulinia coloradoensis* show that this once-dominant species thrived when salinity was lower than at present. The reduction in the number of shellfish has probably meant a diminished food supply for migratory waterfowl. Upstream dams and irrigation projects have profoundly changed the diversity and biological productivity of the Colorado River Delta in Mexico. Prehistoric shells can be used to reconstruct past diversity, composition, abundance, ecological interactions, growth rates, survivorship, salinity regimes, and environmental preferences. Dead shells provide a baseline to assess environmental impact in coastal areas.

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#### POLICIES FOR MANAGING LANDSCAPE CHANGE: LESSONS FOR HABITAT CONSERVATION.

Conservation of wildlife habitat is assisted through public policies directed at land use choices. A wide range of public policies have been applied at varying spatial scales to achieve ecological, social and economic goals in managing landscapes. An extensive literature describes policies for managing landscape change, but few evaluations of policy effectiveness and impacts have been conducted. A framework for analyzing landscape change policy and program

evaluations is presented; such policies range from urban growth management, to preserving natural habitat. The full range of policy tools for managing landscape change are classified, including regulatory, incentive-based, and voluntary. Lessons for policy makers, planners, and scientists include observations that: 1) spatial scale and political level should be carefully considered; 2) collaborative and incentive-based approaches may be associated with greater policy effectiveness; and 3) a dearth of empirical evaluations have been carried out. Researchers have only recently begun the task of evaluating the successes and failures of landscape change policy approaches and programs, and little is known about their effectiveness or impacts (ecological, social, economic) in spite of the longevity of some of these policies (e.g. the first state-wide growth management efforts began in Hawai'i in 1961).

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#### EFFECTS OF HISTORIC LIVESTOCK GRAZING AT CHACO CULTURE NATIONAL HISTORIC PARK, NEW MEXICO.

Livestock grazing is the most ubiquitous land management practice in western North America, yet it has rarely been studied in a controlled manner due to lack of large areas free of grazing. We compared the ecological effects of three grazing treatments--long-term protection, short-term protection, and currently grazed--at Chaco Culture National Historic Park (CCNHP) in northern New Mexico. CCNHP has a long history of human habitation, and is now one of the largest grazing enclosures in the American West. The effects of livestock grazing on shrub, grass, and soil crust cover and plant diversity were studied at six sites with different potential natural vegetation. Species richness was higher under long-term protection than current grazing at all six sites. There was significantly greater cover of potentially nitrogen-fixing black soil crusts at all six sites. Trends in shrub and grass response varied with the site's potential; shrub cover increased with long-term protection at 4 upland sites, and grass cover increased with protection at 4 sites. The complexities of shrub "invasion" and the role of biological potential in driving post-grazing succession will be discussed. From a conservation biology perspective, these results affirm significant ecological impacts by livestock grazing in the semiarid West.

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#### BRINGING SCIENCE AND INNOVATION TO SAVING EARTH'S BIOLOGICALLY RICHEST AND MOST ENDANGERED ECOSYSTEMS.

Conservation International's (CI) mission is to conserve our planet's biodiversity and demonstrate that human societies can live harmoniously with nature. In 1998, with a major grant from the Co-Founder of Intel Corporation, Gordon Moore, and his wife Betty, CI launched the Center of Applied Biodiversity Science (CABS) to focus on generating and disseminating science-based information to support the broader goals of the conservation community. Anchored on multi-institutional partnerships, the mission of CABS is to strengthen our ability to accurately identify and quickly respond to the emerging threats to Earth's biological diversity. CABS draws together its own researchers with other scientists in universities, research centers, multilateral government and non-governmental organizations around the world to tackle the urgent, global-scale questions of conservation science. Established partnerships span over 30 research fellows in 40 institutions distributed in 12 countries. Through this effort, CABS mobilizes leading experts in science and technology to collect and interpret data about biodiversity. Armed with this information, CABS and its partners develop strategic plans for conservation, forge key partnerships to promote conservation goals, and invigorate public awareness of and involvement in the challenges we face in saving the planet's living resources.

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#### NATIVE HAWAIIAN STREAM FISHES: DIFFERENTIAL IMPACTS OF NATIVE AND EXOTIC PARASITES.

Threats from parasites to the conservation of native Hawaiian stream fishes have been assessed. Two sources have been identified for species of native helminths presently parasitizing these native gobioid fishes: marine fishes and piscivorous birds. During their marine planktonic phase, amphidromous stream fish larvae occasionally acquire juvenile stages of marine fish helminths when feeding on copepods. Stream fishes are considered dead-end hosts for these rare parasites. Naturally colonizing birds such as herons have been responsible for introduction of helminths that use stream fishes as intermediate hosts. Because of their scarcity, native helminths are not likely to present disease threats to Hawaiian stream fishes. Exotic helminths have invaded Hawaiian streams as parasites of alien fishes, principally livebearers (Poeciliidae), introduced for mosquito control and as aquarium escapees. These broadly specific parasites, including a roundworm *Camallanus cotti*, a tapeworm *Bothriocephalus acheilognathi* and a leech

*Myzobdella lugubris*, have transferred from exotic to native fish hosts and now are the most widespread of all stream fish parasites. Because of their high prevalence and intensity, potential for pathogenicity, and rapid rates of transmission, these three exotic parasites represent the greatest disease threat to the conservation of native Hawaiian stream fishes.

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#### SUSTAINABILITY OF HAWAIIAN DROSOPHILA IN MANAGED LANDSCAPES OF HAWAII VOLCANOES NATIONAL PARK.

Approximately one third of the world's species of *Drosophila* occur only in Hawai'i, including giant "picture-wing" flies with bizarre legs and mouthparts. These flies are illustrated in many biology texts as a premiere example of historical biogeography and the radiation of species. Over the past three decades, Hawai'i Volcanoes National Park has lost approximately 10% of its picture-wing fauna. Local species richness at bait stations has declined much more dramatically. O'laa Forest, for instance, has lost 4 of 14 species. Mark-recapture data supports the contention that populations of individual species have declined dramatically. Morphological and genetic data suggest that hybridization is also occurring between species. The causes of picture-wing decline appear to include the loss of host plants, introduction of alien predators (such as the Western yellowjacket wasp in 1978), and reduction in overall habitat. All of these limiting factors are being remedied under current park resource management programs. In January 2001, the U. S. Fish and Wildlife Service proposed listing twelve species of Hawaiian picture-wing *Drosophila* under the Endangered Species Act. Long-term sustainability of picture-wing populations may depend on a combination of population protection and active habitat restoration such as that currently underway in the park.

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#### THE EFFECT OF OTHER SPECIES ON COLONIZATION RATE AND FITNESS OF MIGRANT BIRD IN A FRAGMENTED LANDSCAPE.

We have earlier shown that some migrant birds use resident birds as a cue of profitable breeding patch. This process, heterospecific attraction, brings about variability on bird diversity among patches with respect to density of residents in the landscape. We further studied the effects of heterospecific attraction on colonization and fitness of Pied flycatchers (*Ficedula hypoleuca*). Study was conducted on nine isolated forest plots embedded on agricultural landscape. Experiment had two treatments: removal and addition treatment of residents (*Parus* spp.) with equal amount of flycatcher nest boxes per plot. Three plots received removal and six plots addition treatment. We predicted that addition plots are colonized earlier and they have higher fitness than birds on removal plots. Male and female flycatchers tended to arrive earlier on resident addition plots. The average hatching day was 1.7 days earlier and the average number of fledglings was 0.6 chicks higher on addition than on removal treatment. The results suggest that the presence and density of species itself is an important characteristics of the landscape potentially affecting colonization and fitness of later arriving species. Fragmentation coupled with heterospecific attraction may hinder later arriving species obtaining potentially good breeding patches, if fragmentation affects negatively the residents.

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#### THE EFFECTS OF ISLAND AREA AND LATITUDE ON SPECIES EXTINCTION RATES.

The Theory of Island Biogeography models the number of species present on an island as a dynamic equilibrium between immigration and extinction rates. An important assumption of the theory is that smaller islands support fewer species relative to larger islands because smaller islands suffer higher extinction rates. While many data are consistent with this hypothesis, there have been few direct tests. We tested if extinction rates decrease with increasing island area by collating information on the fates of 151 deliberate introductions of six mammal species (pigs, goats, sheep, rabbits, cats and possums) to 84 of New Zealand's offshore islands. The introductions occurred decades to centuries ago, and the islands varied in size from 0.4 – 175,000 ha. Extinction rates for all six species did decrease with increasing island area. However, extinction rates also decreased with decreasing latitude, and this effect was far stronger than that of island area. Our results therefore confirm that smaller islands do experience higher extinction rates, and provide a mechanism for understanding how latitude can shape range-size.

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#### POLLINATION BIOLOGY OF TWO MAUI ENDEMICS: POTENTIAL IMPACTS OF ALIEN INSECTS ON PLANT REPRODUCTION.

Alien species can potentially disrupt interspecific interactions in ecological communities. I investigated the pollination biology of two Maui endemics in the Hawaiian Silversword Alliance, *Argyroxiphium sandwicense* ssp. *macrocephalum* and *Dubautia menziesii*, and examined the impact of alien ants and bees on plant reproduction. I measured self-incompatibility, the relative effectiveness of different insect visitors as pollinators, and the degree of pollen limitation in each plant species. I assessed Argentine ant (*Linepithema humile*) impacts on plant reproduction by comparing seed set in ant-infested and non-infested areas. *A. sandwicense* and *D. menziesii* are both strongly self-incompatible, and are dependent on insect-mediated pollen transfer. In both species, pollination is effected by diurnal visitors, primarily native yellow-faced bees (*Hylaeus* sp.). Honeybees are common visitors, but are not effective pollinators. *A. sandwicense* was pollen-limited in non-infested areas in both 1998 and 1999, while the more widespread *D. menziesii* was not pollen-limited in either year. In 1997, *A. sandwicense* was pollen-limited in ant-infested areas, but not in non-ant-infested areas. Reduced seed set in ant-infested areas may be due to reduced numbers of *Hylaeus* in these areas. Results suggest that alien insects may decrease seed set in native plants through competition with, or predation on, native pollinators.

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#### AVIAN POPULATION TRENDS IN THE ALAKAI SWAMP, KAUAI: NATIVE DECLINES AND EXOTIC EXPANSIONS?

The Hawaiian avifauna has declined severely since human colonization, with losses exceeding 80 native bird species. Kauai's Alakai Swamp, the only remaining native forest bird habitat on the island, has not been immune to the problems plaguing Hawai'i's birds, where five native bird species have gone extinct within the last 30 years. We conducted avian surveys of the entire Alakai Swamp in March and April 2000 and compared them to a similar survey from 1973 to determine long-term population changes of native and introduced species. Our work revealed unchanged or increasing bird populations for five of the seven most common native species. At least four introduced species increased in number, one was extirpated, and one new species invaded. Additionally, when compared to surveys conducted in the interior of the swamp in 1981, 1989, and 1994, only two native species in the 2000 survey showed significant population declines. Thus, most native bird populations in the interior and periphery of the Alakai Swamp remain healthy despite numerous limiting factors. Nonetheless, the avifauna of Kauai remains extremely vulnerable and active management of introduced plants, animals, and disease is essential in preventing further habitat degradation and native bird loss.

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#### HABITAT USE OF MALE AND FEMALE HINE'S EMERALD DRAGONFLY, *SOMATOCHLORA HINEANA*, A FEDERALLY LISTED SPECIES.

Understanding habitat requirements of endangered species is key to ensure their protection. Knowledge of the distribution and habitat use of female Hine's Emerald Dragonfly is limited. At two sites in Door County, Wisconsin, we monitored male and female Hine's Emerald Dragonfly (HED) in breeding and non-breeding habitats. Two to four netters, with at least one netter in each habitat type caught, sexed, recorded behavior, and individually marked HED with bee tags. Sampling was conducted between 10AM and 3PM on sunny days with low winds. Netting sessions consisted of 3-50 minute periods repeated 3-4 times at each site. Females were more abundant in the non-breeding habitats representing 70% of the HED caught there. Female use of non-breeding habitats was highly variable and may be influenced by temporal availability of food resources. Males were more abundant in the breeding habitats, however the sex ratio there was less consistent and ranged from 50% to 80% male. This study links wetlands to their adjacent habitats and demonstrates that preserving both is important for the management and recovery of the Hine's Emerald Dragonfly. These links may be equally as important for other wetland species that depend on terrestrial habitats for part of their lifecycle.

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#### INVASIVE PATHOGEN THREATS TO BIRDS ON ISLANDS: LESSONS LEARNED FROM HAWAII AS APPLIED TO THE GALAPAGOS.

Introduced diseases like avian malaria and pox have been implicated in the extinction of birds in Hawai'i and other places. The Galapagos islands harbor a unique set of endemic birds and have suffered few, if any extinctions. Nonetheless, some avian populations are now in decline and several exotic pathogens appear to have already been introduced to the islands. This talk outlines the conclusions from an October 2000 workshop that evaluated the potential threat of diseases and parasites to the avifauna of the Galapagos. A panel of 27 scientists and managers identified the most likely avenues of invasion, as well as the pathogens posing the highest risk to local bird populations. Some of the recommendations made to prevent the introduction and spread of exotic diseases include the establishment of a realistic monitoring system, enhancements to the current quarantine program, the evaluation of different intervention options and the establishment of contingency plans. These guidelines can be adapted to birds or other vertebrates on other oceanic islands.

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#### HOW DEMOGRAPHIC VARIATION AMONG INDIVIDUALS AFFECTS EXTINCTION RISK OF POPULATIONS.

Individuals in populations have differing demographic properties. We have recently shown that treating them as identical (as in PVA models) causes potentially serious misestimation of the importance of demographic stochasticity. Here we present results on how demographic variation among individuals affects extinction risk. We can calculate these effects by using the sensitivity analysis of a demographic model to estimate the variance of the population's growth rate. Populations experiencing high variance in their growth rate are at increased risk of extinction. In comparison with a population of identical individuals, variation among individuals in survival always reduces the effect of demographic stochasticity, and thus decreases the extinction risk. Variation in fecundity has more complicated effects: it can either increase or decrease the extinction risk, depending on whether variance in fecundity has a convex or a concave relationship to the mean fecundity.

FRANKHAM, RICHARD. Department of Biological Sciences, Macquarie University, Sydney, NSW 2109, Australia. POPULATION SIZE, GENETIC DIVERSITY AND CONSERVATION.

Genetic diversity is of conservation concern as it is required for evolutionary change. Further, loss of genetic diversity is related to inbreeding and this reduces reproductive fitness and so directly increases extinction risk. Endangered species have, by definition, small, or declining populations. Theory predicts that loss of neutral genetic diversity is related to effective population size. Experimental data indicates that heterozygosity is related to population size for both molecular and quantitative measures of genetic diversity, as predicted. The main reason for deviations from the predicted relationship between heterozygosity and population size in small populations is associative overdominance. Quantitative genetic variation determines evolutionary potential, but overwhelmingly information on genetic diversity comes from molecular measures. Based upon a meta-analysis, molecular measures of genetic diversity are only weakly related to quantitative genetic variation, and there is no relationship for fitness characters. The predicted relationship between genetic diversity and population fitness has been confirmed in a meta-analysis. Evolutionary change in the medium to long-term depends upon initial additive genetic variation, upon effective population size and upon reproductive excess. Consequently, most endangered species have severely compromised ability to evolve as compared to non-endangered species.

FREED, LEONARD A. Department of Zoology, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA. LIFE HISTORY CHARACTERS UNDERLIE ENDANGERMENT IN HAWAIIAN HONEYCREEPERS.

While causes of endangerment are well known in general for individual species, particularly plants, less attention has been directed on determining why some animal species in a community are endangered and others are not. Hawaiian Honeycreepers (Drepanidinae) provide a system for studying comparative endangerment. Based on census data from the Hawai'i Forest Bird Survey, there is a strong correlation between distribution and abundance of six species of nectarivorous and insectivorous Hawaiian Honeycreepers on the Island of Hawai'i. Three of these are listed as endangered and, not surprisingly, these taxa have more restricted range and lower density than the unlisted taxa. A comparison of life history characters, such as habitat selection, clutch size, number of broods, and duration of the

fledgling period, reveals substantial differences between the endangered and unlisted species. In all of these characters, endangered species are more conservative than unlisted species. One implication is that endangered honeycreeper populations are more susceptible to habitat disturbance and slower to recover. A second implication is that the lower reproductive rate decreases the rate at which new alleles appear that may be relevant for adapting to novel selective pressures.

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CONSERVATION STATUS OF ANTPITTAS IN THE GENERA *GRALLARIA* AND *GRALLARICULA* (FORMICARIIDAE) IN ECUADOR: AN ASSESSMENT OF CONSERVATION STATUS RANKING MODELS.

*Grallaria* and *Grallaricula* antpittas are among the least known birds in the Neotropics, making conservation status assessment inaccurate. Due to their restriction to dense forest interior most of them are highly vulnerable to habitat alteration and fragmentation. I evaluated the conservation status of eighteen species recorded in Ecuador based on data on their geographic distribution. Using the IUCN evaluation model, two species previously considered as Endangered were ranked as Vulnerable, and two species not previously included in any threat category were ranked as Endangered. Only one species was ranked in the same category as before. These marked differences reveal the importance of basic distributional data on poorly-known species for improving the accuracy of their status ranking. Another evaluation model was also used in the species conservation status analysis. This model takes into account the habitat restrictions for each species, the current threat status of their habitats, and the protection level of their ranges within the country. Five species were classified as Near-threatened, one as Vulnerable and one as Endangered, with only one species having the same status as proposed by the IUCN system. This alternative model requires further evaluations to assess its limitations and applicability.

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RELATIONSHIP OF FOOD AVAILABILITY TO DISTRIBUTION AND ABUNDANCE OF THE HAWAII'I AKEPA.

Extinction rates among Hawaiian forest birds have been high since humans colonized the islands. Habitat loss, introduced predators, and diseases have been implicated in these losses and are thought to limit existing populations. However, no studies have explored the importance of food to avian populations in wet and mesic forests. I developed methods to estimate food availability for the endangered, insectivorous Hawai'i Akepa (*Loxops coccineus coccineus*) at site where akepa persist in relatively large numbers. I explored the relationship of food availability to reproductive success, and then used this baseline data to explore the interaction of habitat degradation and food at a site where akepa have declined drastically. I found that food is associated with reproductive success at the site where akepa are abundant. At the site where akepa are rare I found no evidence of direct disturbance to the arthropod community that provide food for akepa. However, integration of habitat structure data with the estimates of food availability per unit of habitat area revealed that food was far lower at that site. These results suggest a role for food in limiting akepa populations, and suggest the need to consider the importance of food at sites where akepa are rare.

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INVASIVENESS OF TROPICAL ASH IN A NATIVE HAWAIIAN FOREST.

Tropical ash (*Fraxinus uhdei*) was introduced in Hawai'i in the 1930s as a timber species and has naturalized in native forests. We re-surveyed 32 plots in the Laupahoehoe forest reserve which were originally established after selective logging for koa (*Acacia koa*) in 1973 and included both native forest and ash stands. Basal area of ash increased from an average of 0.8 m<sup>2</sup>/ha in 1973 to 9.9 m<sup>2</sup>/ha in 2000. However, ash did not spread more than 500 m from where it was found in 1973. Basal area of native trees also increased slightly, from 18.9 m<sup>2</sup>/ha to 19.8 m<sup>2</sup>/ha, with koa showing an increase and *Metrosideros polymorpha* and other native species decreasing. Abundance of tree ferns (*Cibotium* spp.) decreased from an average of 47 stems/ha to 9 stems/ha. Basal area of native trees and number of understory species were both inversely related to basal area of ash. Ash seed rain was heavy, with up to 16,000 seeds/m<sup>2</sup> collected in six months. If the ash plantation is opened up for harvest, managers should plan ways of regenerating the more valuable native koa rather than the ash and preventing the spread of ash into adjacent native forest.

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#### INCORPORATING TEMPORARY EMIGRATION IN MARK-RECAPTURE STATISTICS.

Mark-recapture statistics are used to estimate survival probabilities of threatened species from capture histories of marked individuals. Such data often include temporary emigration of individuals from the study area, which causes biased estimates of survival. Emigrated individuals have a true capture probability of zero, but mark-recapture methods assume all individuals, inside or outside of the study site, have the same non-zero capture probability. This results in under- and over-estimation of the capture probability for individuals inside and outside of the study site, respectively. Because capture probability is inversely related to survival probability in the likelihood function, estimated survival probability is biased. Here, we present new statistical methods to estimate survival probability from mark-recapture data including temporary emigration. We show how to solve this problem by using stage-structured models that include one or more stages that represent individuals that have temporarily emigrated, and computing the likelihood function from this stage structure. We apply the method to simulated data representing different life histories, for which underlying parameter values are known, and demonstrate unbiasedness of estimators. Our results apply to seabird, sea turtle, and marine mammal data where individuals are sampled only on their breeding grounds.

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QUANTITATIVE MOTION ANALYSIS AND SPATIAL DYNAMICS OF SNOWSHOE HARES IN DIFFERENT HABITAT TYPES.

Snowshoe hares are the primary prey of the federally Threatened Canada lynx. Forest structure affects hare population dynamics, and the U.S. Forest Service has ceased pre-commercial thinning of National Forest in the Northern U.S. until this relationship is understood. As part of a larger study investigating snowshoe hare population dynamics, we employed a novel, theoretical approach – Quantitative Motion Analysis (QMA) – for assaying fitness without having to capture the animal (i.e. a non-invasive sampling approach). During two winters across four forest thinning treatments in Northwestern Montana, we located radio-collared hares and backtracked their paths over snow. We measured turning angles, distance to shelter, and behavior for 70m of path, and compared the tortuosity (lack of directional bias) of paths in each treatment. Using this information as a baseline, we elicited realistic predator-avoidance behavior by flushing hares with a domestic dog. Tortuosity, considered indicative of habitat fitness, was highest in closed mature forest (.59), but dropped to .28 in open young forests. Hares in predation trials exhibited similar tortuosity to open young forest (.23), implying that pre-commercial thinning decreases habitat value for hares. We believe QMA may be a useful supplement to traditional invasive approaches that evaluate wildlife responses to human perturbations.

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#### EVIDENCE, DIRECTION, AND EFFECTS OF INTERSPECIFIC HYBRIDIZATION IN FRAGMENTED POPULATIONS OF *PINUS* SPECIES.

Disturbance due to agriculture and the harvest of trees for fuelwood and for timber has resulted in a sharp reduction in the population numbers of many of the tropical pine species. It is proposed that fragmentation accelerates the process of interspecific hybridization and that such hybridization may increase genetic diversity and diminish genetic integrity of individual tree species. Population-level assessment of RAPD marker diversity yielded several species diagnostic markers potentially useful in the assessment of interspecific hybridization for a number of pine species. Populations of *Pinus tecunumanii* and *P. caribaea* were collected from the Mountain Pine Ridge, Belize, an area that has undergone extensive fragmentation and where these two species are sympatric. Many individual trees in these populations appear to be morphologically intergraded. RAPD marker data on individual trees suggest that interspecific hybridization is occurring, as individuals contain a number of marker loci considered diagnostic for the alternate species. Chloroplast microsatellite data were obtained to investigate directionality of hybridization, as chloroplasts are paternally inherited in pine. These populations provide an invaluable resource for studying the effects of fragmentation on both genetic structure and diversity, the results of which would be immensely valuable for planning and implementing global conservation efforts.

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#### **PUBLIC REWARDS AS PATHWAYS TO SUCCESS IN ECOLOGICAL RESTORATION: THE TIRITIRI MATANGI ISLAND (NEW ZEALAND) EXPERIENCE.**

Slow rates of natural revegetation and limited funding are common factors that impact on the success of ecological restoration projects. Public involvement on Tiritiri Matangi Island, New Zealand, has shortened the restoration time frame and has allowed access to funding unavailable to government authorities. Public involvement on Tiritiri Matangi was initiated in 1984 with a replanting program using volunteers from conservation groups. This involvement has since broadened to encompass a wider cross-section of the community contributing to an increasing range of management and advocacy activities, firmly establishing public partnership in the project. On-going 'rewards', such as open access to a scientific reserve and participation in the release of translocated species, have sustained public interest in the project and facilitated advocacy for conservation. The establishment of a non-profit non-governmental organisation, the Supporters of Tiritiri Matangi, has enhanced and reinforced the opportunities for rewards, with the organisation itself contributing significantly to the project's success. The involvement of public was innovative (and controversial) at the time that the project was initiated, but is now an accepted, and indeed expected, management strategy in New Zealand conservation. The establishment of an autonomous management system with representation of key stakeholders is currently being explored.

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#### **CURRENT SITUATION OF CUBAN GLOBALLY THREATENED BIRDS: CASE STUDIES OF CONSERVATION PROGRAMS.**

In 1974 Buide et al. listed 21 species of Cuban birds as threatened. Twenty years later, Perera et al., and Gonzalez and Llanes listed 46 and 17 species, respectively, as having conservation problems. Bird Life (1998) considers 24 Cuban species to be globally threatened. We evaluated the status of the 20 bird species mentioned by most authors, of these 13 are forest residents and 9 are endemics. All forest and some savannah species are threatened by habitat degradation and fragmentation. Unjustified killing of "predators" (Cuban Kite and Gundlach's Hawk), poaching of nests and adults (Cuban Parrot and Cuban Parakeet), and illegal hunting (Plain Pigeon, West Indian Whistling-Duck and Cuban Sandhill Crane) are additional causes of endangerment. 100% of threatened species are represented in over 73 protected areas established for their conservation, many with infrastructure and specialized field staff conducting management and research. The Parrot, Parakeet and Crane conservation programs are the most advanced and new programs for other species are being initiated. Conservation of endangered species have been linked to educational programs targeted to city and rural communities. The charismatic, endangered species have served in Cuba as "umbrellas" under which ecosystems are conserved by generating support from the local population.

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The California Channel Islands were the site of many introductions of domestic livestock that eventually went feral. The four federal agencies or private organizations that administer the islands independently determined that feral animals were causing sufficient long-term environmental damage that their removal was mandated. Between 1972 and 1991 the US Navy removed 28,000 feral goats and 2,200 feral pigs from San Clemente Island using a combination of live-capture/transport and lethal measures, leaving the island free of exotic herbivores. On Santa Rosa Island, the US Park Service successfully eradicated feral pigs over a 3-year period. On Santa Cruz Island, The Nature Conservancy lethally removed 37,000 feral sheep over 5.5 years on 90% of the island. The remaining 9,700 sheep were recently removed by the US Park Service. On Santa Catalina Island, animals removal is on-going, with over 8,000 feral goats and 11,000 feral pigs removed primarily by shooting. Most of these programs have spanned several years, have been challenged by animal rights groups, and have cost hundreds of thousands to millions of dollars to complete. Eradication of introduced animals can be successful if sufficient resources and commitment are dedicated to the project.

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## FREE RANGING PARROTS ON MAUI, HAWAII: DISTRIBUTION, THREATS AND CONTROL POSSIBILITIES.

Ten parrot species have been documented from Maui since 1977. The most detectable species to date occupying the windward lowland rainforest on East Maui are the mitred conures (*Aratinga m. mitrata*). Originating from a pair of pet birds released in 1986/87 in Huelo the population is now estimated to be 150 to 200 birds. Our observations showed that these birds roost in seacliff areas from Waipio-nui to Huelo point, forage in higher valleys during early morning and late afternoon hours. They fly mostly in pairs or triplets in noncohesive flocks of up to 50 birds. We saw them feeding on Chinese banyan (*Ficus platypoda*), common guava (*Psidium guajava*) and rose apple (*Syzygium jambos*). The rapid mitred conure population growth, expanding range, potential to transmit diseases to Hawaiian birds and the proven dispersal of nonnative tree species, poses serious threats for native Hawaiian flora and fauna. Furthermore, the ability to damage commercial fruit and seed farms is an economic concern. This poster provides baseline data about the dynamics, range and feeding pattern of mitred conures on Maui. Maui's parrot distribution is mapped and possible management techniques are presented.

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## EFFECT OF SPATIAL ISOLATION (FROM ROADS) ON NATIVE AND EXOTIC PLANT DIVERSITY.

We examined the effect of isolation from roads on native and exotic plant diversity in a California foothill grassland landscape. We measured native and exotic plant diversity and cover in sites stratified by isolation (10 m, 100 m, and > 1000 m from roads), soils (serpentine and non-serpentine), and slope (cool, warm, and neutral). In non-serpentine grasslands, native cover was greatest in sites > 1000 m from roads (22%) and least in sites 10 m from roads (8%), and habitats > 1000 m from roads contained a significantly greater percent of native species (44%) than those 10 m (29%) or 100 m (35%) from roads. In serpentine grasslands, the percent of native species and native grass and forb diversity were greatest in isolated sites. Two exotic species that have recently been observed to be spreading (*Aegilops triuncialis* and *Centaurea solstitialis*) were least prevalent, and one native bunchgrass (*Nassella pulchra*) was most prevalent, in isolated sites. Native species were generally most prevalent on infertile sites on both soil types, and were most prevalent on cool, ungrazed slopes on nonserpentine soils. Roadless areas are significant refuges for native species, but careful management is important to protect these habitats from continued invasion.

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## DEMOGRAPHIC SENSITIVITY ANALYSIS AS A TOOL FOR MARINE RESERVE DESIGN.

I will explore the idea that a sensitivity analysis conducted on stage-specific demographic rates can be used to help guide the design of marine reserves, whereby reserves target life history stages for which protection will accomplish the most in terms of fostering population growth. In the marine realm, an interesting facet of pleas for reserves is that most reserves are quite small in area, and represent only a small portion of the total range of species. Recognizing that we may not be able to protect all portions of the range for wide-ranging marine organisms, I use demographic analysis to help focus management efforts on critical life stages for a representative range of species life history characteristics. We synthesize data for marine mammals, fish and marine invertebrates and cluster species by elasticity in order to identify critical life history stages to be targeted in marine reserve. Our results indicate that reserves for marine mammals may have fundamentally different goals than those for fish and invertebrates (i.e., protection of juveniles in fixed spatial locations vs. protection of adult rockfish). Standardized demographic analysis may be useful in identifying disparate conservation goals for marine reserve design for species with distinct life histories.

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## EFFECTS OF HISTORIC DEFORESTATION ON GENETIC DIVERSITY OF OLD-GROWTH AND SECONDARY *QUERCUS RUBRA*.

Most forests of New England were cleared in the last 200 years. This study assesses the genetic consequences of this deforestation by comparing genetic diversity of old-growth (OG) and secondary *Q. rubra* populations in four areas of Massachusetts. These areas underwent a reduction of forest cover from >80% to as low as 29% in the mid-1800s, followed by recovery to the current level of >70%. Genetic diversity was assessed using six nuclear simple sequence repeats (SSRs) and three chloroplast SSRs. *Q. rubra* stands in all four areas show high within-stand diversity and low differentiation between stands. Chloroplast SSRs show greater differentiation than nuclear SSRs, consistent with short-distance seed dispersal. Preliminary data show no correlation between forest history and allelic richness of

chloroplast SSRs, but nuclear SSR data show that OG stands contain 32 alleles lacking in the secondary stands, while secondary stands contain only 17 alleles lacking in OG. This may be due in part to lower secondary sample sizes. These data suggest that historic deforestation in Massachusetts may have caused a loss of allelic richness. Thus, OG stands may be valuable genetic resources that should be preserved to enhance long-term evolutionary potential of the species.

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#### SACRED FORESTS AS MODEL CONSERVATION ISLANDS.

Sacred groves are relict forest pockets with harvests prohibited or regulated by the local people under religious pretext. Ranging from few trees to hectare in size, such groves represent several small conservation islands scattered all over the country. Tree enumeration along 0.1 ha strip transects reveals that these forests are no less diverse but shelter more rare or keystone or endemic species than the surrounding landscape, including large forest patches. Compared to larger, harvested forest patches in the neighbourhood, sacred groves harbour greater proportion of primitive and animal dispersed but lower proportion of animal pollinated trees. Higher assemblage diversity amongst groves as evident from higher beta diversity between transects distinguishes their conservation potential relative to larger forest patches. Their vital ecosystem and social services confer them long-term sustainability and competitive advantage in the context of SLOSS debate. Groves reconcile social and ecological concerns and offer important lessons for the state driven protected areas (PA) paradigm that employs few large wildlife reserves, threatened by industrial exploitation besides villager's resistance given curbs on their livelihood activities. In contrast, despite its recent erosion driven by socio-economic changes, the sacred groves tradition still shows signs of restoration and resurgence.

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#### THE ASTROLABE ISLANDS OF FIJI: STATUS OF THE TERRESTRIAL VEGETATION.

Eleven islands lie in the Great Astrolabe Lagoon of Kadavu, Fiji. The largest three islands are inhabited, have subsistence and commercial plantations while five other islands are used as pastures for goats. A survey of the vegetation of all islands showed that species richness was higher in the inhabited islands but that they contained more introduced species (39% to 47% of total species). Species richness on goat-grazed islands was low (24% to 12%) and contained a higher proportion of grasses. Over-grazing resulted in soil erosion, exposed tree roots and bare rocks. An uninhabited island with least disturbance had the most native species (95%) with several species not found on other islands. In terms of conservation, the vegetation of goat-grazed islands is vulnerable and loss of species through natural phenomenon may result in the local extinction of rare or endemic species. Lack of soil cover would make the establishment of species impossible. On small oceanic islands where the natural establishment of species is dependent on several abiotic factors including suitable coastline, currents and substrate, and where the natural loss of species can occur through cyclones, man-made disturbance must be kept at a minimum to avoid habitat and species loss.

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#### THE NATIONAL NATURAL LANDMARKS PROGRAM: A CONSERVATION PROGRAM ISOLATE BUT IN NEED OF CONSERVING.

Established by the Secretary of the Interior back in 1962, the National Natural Landmarks (NNL) Program is an honorary designation that recognizes the conservation efforts of state and federal agencies, along with private landowners. Unlike its much more recognizable National Historic Landmarks (NHL) sister-program, the NNL program has managed to sustain itself amidst a self-imposed, but necessary, moratorium and repeated attacks from program detractors. This feeling of isolation frustrated program officials for over a decade until the lifting of the servicewide moratorium in 1999. In retrospect, this scrutiny has proven to be a godsend both for the 587 existing NNL's, as well as, strengthening the resolve of the National Park Service to build upon an already successful conservation program. From well-known Diamond Head NNL, Hawai'i to little-known Dinosaur Trackway NNL, Connecticut conserving biological and geological resources in partnership with all people is the name of the game, or better put, the National Natural Landmarks Program.

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## CAN ROAD MORTALITY LIMIT TURTLE POPULATIONS?

All tortoises and about one third of aquatic and semi-aquatic turtles in the United States currently require conservation action. Turtle life histories are characterized by high adult survival rates and delayed sexual maturity, which together severely constrain the ability of turtle populations to cope with additive mortality sources. We examined the potential for road-associated mortality to limit regional turtle populations by integrating simulations of turtle movements with maps of actual road networks and the traffic volumes upon them. Combinations of road density and traffic volume in the Northeastern, Southeastern, and Great Lakes regions were predicted to generate annual additive road-associated mortality in land turtles well in excess of 10%, a threshold level of additive mortality most turtle species likely cannot absorb and still maintain positive population growth rates. States in the Pacific, Mountain-Prairie, and Southwest regions were at or below the threshold. We conclude that the demographic traits of land turtles in combination with their mobility jeopardize their persistence within the road networks characteristic of many regions of the United States. This may place land turtles in the company of grizzly bears and gray wolves as fauna for which road networks may be a key limiting factor to population recovery efforts.

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## ISLANDS AND CONNECTIVITY IN AN EPIDEMIC OF AN INVASIVE PALM DISEASE IN KUNA YALA, PANAMA.

Porroca is a newly emerging, invasive, lethal disease of coconuts in Panama. Formerly restricted to areas around Cartagena, Colombia and the Panama-Colombia border, the disease recently entered an epidemic phase, spreading along the Caribbean coast and inland to 40 km west of the Panama Canal. In 1998, 1999, and 2000 we mapped and determined the health status of several hundred thousand coconut palms on more than 300 km of coastline and 300 islands in the Comarca of Kuna Yala, the indigenous reserve of the Kuna Nation. Disease infections were patchy, mostly restricted to mainland sites, and most severe in long stretches of contiguous coconut palms. During the study period there was a 13-fold increase in the number of infected islands, but with most new infection sites restricted to a small number of palms. Epidemiological patterns indicated rare long-distance dispersal of the pathogen is important in establishment of the disease in previously uninfected coastal areas and islands, and that continued disease development is highly dependent on local conditions. Coconut is the primary economic resource of the Kuna, and loss of coconuts is likely to have a major impact on management intensity of their forest resources.

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## SOURCES, SINKS AND MANAGEMENT OF LANDSCAPE SPECIES: THE AFRICAN WILD DOG.

Landscape species use large, ecologically diverse areas. Their requirements in time and space render them especially susceptible to human use and alteration of natural landscapes. Using data from a five-year study in Zimbabwe, and from the literature, we examine how movement across a matrix of human land-use types affects the persistence of a population of African wild dogs (*Lycaon pictus*). Our analyses suggest that restoration of habitat in a human-dominated matrix (population sink) can have the perverse effect of drawing wild dogs out of a protected area (population source) thus reducing the short-term probability of persistence of the population overall. Such complex dynamics suggest that if restoration efforts are to be successful for wide-ranging species they must address direct and indirect causes of human-induced mortality across a landscape.

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## MHC DIVERSITY IN CONTINENTAL ISLANDS OF SOUTH AMERICAN CREOLE CATTLE.

Genetic diversity at the major histocompatibility complex (Mhc) has been shown to be important for the organisms' adaptive immune response. The predominance of polymorphisms at peptide binding sites of Mhc molecules, even allele frequency distributions, and excess of non-synonymous substitutions suggest that balancing selection may be the major evolutionary force driving Mhc dynamics. Genetic analysis of the MHC-DRB3 locus from 11 populations of South American Creole cattle suggests that founder events and genetic drift may have played important roles in the maintenance of genetic diversity in this system. Both average expected heterozygosity (0.845) and allelic diversity (13.4) varied considerably among populations. We detected 33 DRB3 PCR-RFLP-defined alleles, with individual

populations having from 9 to 22 alleles. All populations showed highly significant levels of genetic differentiation ( $F_{ST}=0.071$ ;  $P<0.001$ ). Contrary to what has been observed in other species, all populations studied revealed no excess of heterozygotes ( $F_{IS}=0.004$ ;  $P=0.061$ ). In addition, neutrality tests showed no evidence for either balancing or directional selection (Slatkin's exact test;  $0.095 < P < 0.856$ ). The characteristic population structure of the South American Creole cattle, with semi-isolated herds and low levels of artificial selection, may have increased the effects of stochastic processes such as founder events and genetic drift.

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#### BALANCING THE VALUE OF SEEDS AND NATIVE SEED PREDATORS IN THE RECOVERY OF THE THREATENED PLANT SPECIES, *SIDALCEA NELSONIANA* (MALVACEAE).

Pre-dispersal predation of seeds by insects is widespread among flowering plants, and among host-specific predators, is generally considered a stable predator-prey system. However, for rare plants already threatened by anthropogenic pressures, seed predation (even at equilibrium levels) may tip the scales farther towards extinction. In this study we examined the efficacy of insecticide application in reducing seed predation by host-specific weevils in the threatened species, *Sidalcea nelsoniana* (Malvaceae). Because these weevils are themselves rare native species, and also host an undescribed parasitic wasp, we continued seed predation measurements the year following treatment to estimate long-term impacts to predators. Results showed that insecticide application dramatically reduced seed predation in the study population to less than 1 percent, compared to a mean 82.5 percent over the previous 2 years, and 66.8 percent in a nearby untreated population. Resulting enhanced seed yields contributed significantly to off-site seed banking and re-introduction projects. In the year following insecticide application, seed predation increased to 28.7 percent, indicating a partial rebound in the predator population. This study suggests that periodic insecticide applications may temporarily bolster seed production in rare, predation-limited plants, without permanently crippling populations of associated native predators.

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#### TROPICAL ASH INVASION INTO NATIVE HAWAIIAN WOODLANDS: AN ANALYSIS OF PHOTOSYNTHETIC CHARACTERISTICS AND CARBOHYDRATE STORAGE STRATEGIES.

*Fraxinus uhdei* (tropical ash), a species introduced to Hawai'i from Mexico, is known to invade disturbed native forests and have higher growth rates when nitrogen is not a limiting factor (Ares and Fownes 2001). We examined physiological, structural, and morphological characteristics of koa and tropical ash to explore possible mechanisms of invasion. Seedlings of both species were grown in a greenhouse under three shade treatments: 100% sun, 60% sun and 30% sun. Structural and non-structural carbohydrates in roots and stems were measured to examine the carbohydrate reserve strategies of both species. Light compensation points, maximum photosynthesis, and dark respiration differed significantly among light treatments but did not differ between the species. A defoliation experiment indicated that ash is much better suited to survive defoliation, especially under low light conditions. Tropical ash had much higher non-structural carbohydrate concentrations in roots and stems than did koa. A significant carbohydrate species by light interaction suggests that koa may not produce enough carbon reserves to survive prolonged periods of stress particularly under low light conditions.

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#### A PALEOBIOLOGICAL PERSPECTIVE ON EXTINCT AND ENDANGERED PRIMATES IN MADAGASCAR.

The work of paleontologists can serve conservation biology in a number of ways. Paleontological data can be used to test models of extinction, including, for example, those derived from species-area curves. They can be used to explore temporal changes in community "ecospace" (or the niche characteristics of species belonging to communities), and to elucidate the differential vulnerability to extinction of distinct guilds or ecological components of communities. They can be brought to bear on the history of still-extant species. Documenting recent cases of geographic range contraction

can help us to understand aspects of the vulnerability of living species that may not be evident from their current population densities and distributions alone. The Late Pleistocene and Holocene records of the primate fauna of Madagascar reveal dramatic changes in the niche characteristics of primate communities and in the geographic ranges of still-extant species. Folivores and seed predators suffered the greatest losses. Some of the still-extant taxa whose geographic ranges were much greater in the recent past than today are *Hapalemur simus* and *Indri indri*. Almost all of the extinct lemurs were (and all of the extant lemurs are) forest-dependent and their extinction/endorsement pattern conforms reasonably well to expectations derived from estimates of forest-habitat loss.

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#### RIPARIAN BUFFERS AND HERPETOFAUNA IN BOTTOMLAND HARDWOOD FORESTS.

We analysed the influence of timber harvest treatment on the spatial and temporal variability of amphibians and reptiles in an East Texas bottomland hardwood forest. The dataset represented a time-series of 5 years post-treatment. A total of 18,645 amphibians and reptiles were captured across 144 pitfall arrays (16 arrays in each of 9 plots; 3 plots in clearcut, select cut, and untreated controls; each plot bisected by one of 3 streams). Pitfall captures represented 46 species (16 amphibians and 20 reptiles). Broad-scale analyses revealed that reptile species richness increased in response to clearcut treatments, while amphibian richness did not seem to respond. The time-series data indicated that site use by species (and species groups) fluctuated, and that these fluctuations were independent of treatment effects. Small-scale (within patch) dynamics revealed that both species richness and relative abundance of common species were confined to specific array locations in clearcut treatments. The spatio-temporally “stationary” refugia in clearcuts were principally contained within the riparian management zone. Richness and abundance hotspots in control and select cut treatments, however, were mobile in space and time.

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#### FERAL CAT HOME RANGE, HABITAT UTILIZATION AND MOVEMENTS ON MAUNA KEA, HAWAII.

Feral cats (*Felis catus*) are predators of palila (*Loxioides bailleui*) and other native forest birds on Mauna Kea. Since 1998, 8-11% of monitored palila nests have been depredated annually by cats. Predation inhibits efforts to restore palila, an endangered Hawaiian honeycreeper. Little is known of the movements, ranges, and habits of feral cats in high elevation dry forests. We captured and attached radio collars to 5 male and 3 female cats and tracked them for 18 months. Male cats occupied much larger ranges than female cats, but did not defend the entire range against other cats. Home range size (10 – 95 km<sup>2</sup>) and overlap (37 – 96%) was highly variable among males. Female cats occupied spatially discrete ranges. Three of the male cats remained on the western slope while two roamed extensively, up to 25 km between sites. This suggests that local control efforts will be complicated by immigration, and that landscape level control will be very difficult.

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#### PREDICTING EFFECTS OF TOP-CARNIVORE COLONIZATION ON MESOCARNIVORES USING ELASTICITY ANALYSES.

Mesopredator release is a phenomenon whereby the absence of a top-predator removes competitive constraints on smaller carnivores, allowing increased population densities of the latter. This in turn may result in dramatic effects on the faunal and floral community. In several regions of North and Central America, terrestrial top-predators are now recolonizing habitat (wolves, grizzly bears, mountain lions) or dramatically expanding their historical range (coyotes). What affects will this have on the populations of mid-sized predators that have been implicated in mesopredator release studies (raccoons, foxes, opossum, skunks, coatis)? Based on information on the life cycle of mid-sized carnivore populations, I use population projection matrices to assess the growth rates and then use elasticity analyses to identify the relative importance of vital rates of various stages. I then examine the behavior of top-carnivores to show the likelihood of these species having a significant impact on the growth rates of mesocarnivore populations. While adult survival is typically the “most important” vital rate, this is not always the case, suggesting that the entry of a top-predator into a region may have varied indirect effects on the community depending on the structure of the mesopredator guild.

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#### WATERSHED PARTNERSHIPS: A MODEL FOR LANDSCAPE SCALE CONSERVATION IN HAWAII.

Effective conservation across large landscapes often requires involvement and cooperation of adjacent landowners whose lands comprise the target landscape. Public-private conservation partnerships, based on mutual interests to preserve watersheds, have become an increasingly popular way to facilitate this kind of cooperation in Hawai'i. The watershed partnerships may involve federal, state, county, and private landowners and managers. In November 1991, major landowners and managers of lands on the windward slope of East Maui formed the East Maui Watershed Partnership. Since then, several other cooperative watershed partnerships have been formed in the Hawaiian Islands, including: West Maui Mountains Watershed Partnership (1998), Koolau Mountains Watershed Partnership (1999), and East Moloka'i Watershed Partnership (1999). Formation of another forest-watershed partnership is underway on the island of Lanai. Although the partners have different mandates, priorities, and constituents, all share a common commitment to long-term protection of watershed resources. It is fortuitous that even when a stakeholder's commitment and efforts are based on protection of water, mitigating threats to watershed landscapes is largely congruent with biodiversity conservation goals. This successful model of watershed partnerships has led to other cooperative management efforts in the state based on mutually agreed upon conservation goals.

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#### USING GIS TO PREDICT THE SPREAD OF AN INTRODUCED SPECIES.

Dispersal has traditionally been modeled and analyzed in ecology by assuming continuous, random spread over homogenous landscapes. Squirrel dispersal on Vancouver Island in Canada has been stratified and non-random over a heterogeneous landscape. I estimated squirrel habitat preference and rates of spread, and then classified the landscape into friction values that reflected presumed ease of movement. Using weighted surface analysis in GIS, I was able to identify the most likely patterns of future squirrel dispersal. This technique could be applied to other systems.

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#### MATCHING THE MATRIX AND METRICS IN THE MAELSTROM.

Understanding the link between habitat characteristics and abundance, density, and productivity of threatened or endangered salmonids is a critical step in recovery planning. To evaluate whether proposed land use may impact fish populations, the National Marine Fisheries Service assesses baseline habitat conditions using a matrix of environmental pathways and indicators. However, the empirical link between this proxy for salmonid population health and actual fish population metrics (density, abundance, productivity, life stage) is not well described. We examined the relationship between fish metrics and categorized habitat conditions from the matrix using data from areas having assessments of fish metrics and baseline habitat conditions. The strength of the relationship of fish abundance/productivity to the categorized habitat characteristics varied with the number and identity of habitat variables exceeding requirements for long-term salmon survival as well as with the spatial scale of data collection. Habitat quality or quantity may thus poorly predict fish quality or quantity due to habitat inaccessibility, incomplete or incorrect habitat or fish information, or other factors driving fish responses. Using more direct measures of fish response to habitat characteristics will better predict how salmonid populations should respond to changes in habitat conditions and should enhance recovery planning efforts in general.

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#### EFFECTS OF ROADS AND POWERLINE CORRIDORS ON SMALL MAMMALS IN AUSTRALIAN WET TROPICAL RAINFOREST.

Roads and powerline corridors restrict small mammal movements in many habitats but little was known of this 'internal fragmentation' in structurally diverse rainforest habitats. Mark and recapture studies in the World Heritage Wet Tropics rainforest of north Queensland, Australia have demonstrated that several rainforest species are inhibited from crossing such 'linear barriers'. In a series of trapping experiments it was shown that degree of movement

inhibition was influenced by several factors. These included the type of habitat in the clearing (grassland, woody weeds, road surface), the presence or absence of canopy above the clearing and the presence of road underpasses with rainforest habitat close to the entrances. Variations in low-level traffic intensity did not increase movement inhibition on narrow rainforest roads. Edge effects in small mammal community composition adjacent to roads and powerline clearings and intrusions by small mammals alien to rainforest habitats were also demonstrated. Several species were observed to use sub-road tunnels as a crossing route. Mitigation of linear clearing impacts on rainforest small mammals may be at least partially achieved by maintenance of canopy closure above clearings, by strengthening of rainforest connections in gullies and by provision of sub-road underpasses.

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#### SPATIAL MODELING TO INVESTIGATE PATTERNS AND PROCESS IN SPECIES DISTRIBUTION FOR CONSERVATION PLANNING.

The distribution of biodiversity and the processes that influence this distribution are poorly understood. In the face of incomplete knowledge, we explore the use of predictive modeling as a surrogate of biodiversity and a way to test hypotheses about processes. We combined current environmental data (i.e. vegetation, temperature, raw radar data) and point localities to create predictive species distribution models for birds in Cameroon, West Africa. We used GIS models to create these distributions and evaluated models with independent point locality data. We used these predictive models as a surrogate of biodiversity and evaluated areas of high species diversity and endemism. To examine processes that may have generated this distribution of biodiversity, we used predictive models in combination with palaeoclimate information. For example, in Cameroon, sister species occur on either side of the “Adamaoua Cliff,” a hypothesized geographical barrier. Predictive species models showed that suitable habitat for a sister species exists on either side of the hypothesized geographic barrier, which indicates that the allopatric species pattern may be a result of the historical barrier and not a change in habitat. Using these methods we generated broader patterns of complementarity, which are important for conservation planning.

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#### FRUIT BAT CONSERVATION IN THE COMOROS ISLANDS: PAST EFFORTS, CURRENT CHALLENGES, AND FUTURE STEPS.

Six bat species, including three Megachiropterans, inhabit the Comoros Islands of the West Indian Ocean. Here we examine the conservation of Megachiropterans in the Comoros. *Pteropus seychellensis comorensis*, and the endemics *Pteropus livingstonii*, and *Rousettus obliviosus* all utilize Comoros’ rapidly disappearing forests for feeding and roosting habitat. Despite challenges including limited resources, poor infrastructure, and infrequent government enforcement of environmental regulations, various organizations working in the Comoros have undertaken conservation projects targeting bats. Action Comores focuses on *P. livingstonii* conservation through ecological research and roost monitoring. Several organizations developed a Species Action Plan for *P. livingstonii*. The World Conservation Union (IUCN) and the Comorian Environment Ministry are executing a five-year biodiversity conservation project that includes outreach, training, development of a Conservation Action Plan for *P. livingstonii*, and research on *R. obliviosus*. To gain local support, any long-term conservation strategy must promote environmental education and conservation-related income generation for rural Comorians. Effective bat conservation must include feeding habitat and roost site protection, long-term monitoring, further research on feeding ecology, population dynamics and reproductive biology of the Megachiropterans, and re-evaluation of the conservation status of *R. obliviosus*. Conservation of the Comorian rainforests may depend on the protection of these keystone bat species.

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#### THE UTILITY OF CONSERVATION EASEMENTS IN PROTECTING LANDSCAPE SCALE SITES.

For many land conservation organizations, conservation easements have become an important tool for protecting large, landscape-scale sites. Conservation easements, legal documents which limit how a property may be used and are binding in perpetuity, provide a flexible and affordable way to protect biological diversity in states such as California, where costs of fee simple acquisitions are high and threats of rapid urbanization are imminent. Since its inception in 1998, The Mount Hamilton Project of The Nature Conservancy has used conservation easements to protect over 75,000 acres of wilderness and open space in the southern region of San Francisco Bay. Use of these easements has allowed The Mount Hamilton Project to design landscape scale protection strategies using relatively few sites (n=6).

Long-term protection, however, is dependent on appropriate site-specific management and monitoring plans. Because this approach involves a more hands-off approach compared with traditional ownership and on-site stewardship, long-term success depends on collaboration with federal, state and local agencies, volunteer programs and university scientists. A statewide review suggests that conservation easements are a viable tool for landscape scale conservation; however, a comprehensive idea of how well this tool works long-term requires more systematic monitoring data collected for at least another decade.

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#### HABITAT SELECTION STABILIZES POPULATIONS SUBJECT TO AN ALLEE EFFECT.

Theoretical studies indicate that a single population under an Allee effect will decline to extinction if reduced below a particular

threshold, but the existence of multiple local populations connected by random dispersal increases stability of the global population. An additional stabilizing process ignored in this literature is the existence of habitat selection by dispersers. Using a simulation model of population change, I found that when habitat patches exhibiting Allee effects are connected by dispersing individuals, habitat selection by these dispersers increases the likelihood that patches persist at high densities, relative to results expected by random dispersal. Populations exhibiting habitat selection also stabilize more quickly than randomly dispersing populations. These effects are particularly important when Allee effects are large and more than two patches exist. Integrating habitat selection into population dynamics may help address why some studies have failed to find destabilized populations, despite well-known Allee effects in many species.

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#### INVASIONS OF ALIEN INSECT PREDATORS IN MID- AND UPPER-ELEVATION DRY FOREST HABITATS ON HAWAII ISLAND, HAWAII.

Alien generalist predators, such as ants and yellowjackets, prey on native Hawaiian arthropods, which can jeopardize food web interactions and ecosystem integrity. We surveyed mid-elevation (1550-2000m) and upper-elevation (2200-2800m) dry forest habitats on Mauna Kea and Mauna Loa volcanoes, Hawai'i Island, Hawai'i, from 1999-2001 to document the distribution and seasonal fluctuations of western yellowjacket (*Vespula pensylvanica*) and alien ant species. Yellowjacket activity varied seasonally in both mid- and upper-elevation sites. Although workers died-off in February and March in the upper-elevations, they were active year-round at mid-elevations, suggesting that nests persist throughout the winter. Six ant species were detected (*Cardiocondyla venustula*, *Linepithema humile*, *Monomorium pharaonis*, *Pheidole megacephala*, *Tapinoma melanocephalum*, and *Technomyrmex albipes*). *L. humile* and *C. venustula* were collected across the widest elevation range and were detected higher than any of the other species, which were all found below 2050m. *L. humile* was distributed in large defined areas, whereas the other species were detected in scattered, isolated pockets. Distributional patterns are likely influenced by vegetation and substrate variation, species interactions, mode of queen dispersal, and origin and time of release. Understanding pest species' distributions, seasonal patterns, and natural histories is the first step in designing a control program.

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#### PATTERNS OF FISH DISTRIBUTION AT THE WATERSHED SCALE.

There is a growing consensus that knowledge of the form, function, and historical context of landscapes is essential to research and management of aquatic ecosystems. In an attempt to gain new insights into fish habitat relationships within, and among watersheds, we are censusing potamodromous populations of coastal cutthroat trout *Oncorhynchus clarki clarki* from 45 third-order watersheds in western Oregon that are isolated above barriers to anadromous fish. A probability-based sample yielded watersheds with a range of land-management activities and landscape-scale variation in geology, geomorphology, and climate. Within-basin variation in physiography, climate, and land management is being assessed at various levels in a spatial hierarchy (e.g., stream, segment, reach, and channel unit). Preliminary results suggest that coastal cutthroat trout are not distributed randomly among channel units, and although there is a strong preference for pools, none of the metrics used to describe pools can be used to predict distribution of cutthroat trout in a watershed. On the contrary, distribution appears to be clustered around dispersed focal points, often associated with tributary junctions. This distribution differs substantially from patterns observed in less extensive surveys, and these results have important implications for future management and restoration efforts.

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#### ACID DEPOSITION, SOIL MINERAL CONTENT, AND BREEDING BIRD DECLINES.

Adequate calcium is required for eggshell formation and chick growth in birds. Studies show that birds living in habitats with low levels of soil calcium can have reduced reproductive success. Magnesium is also important for eggshell development, and like calcium is selectively ingested by reproducing female birds. We hypothesized that population trends of birds could be predicted by soil mineral content and acid deposition, which can deplete soil minerals. We evaluated bird population declines of seven forest-specialist species in the northeastern U.S.A. relative to soil calcium and magnesium content, soil pH, and acid deposition for two 20-year time spans since 1968, and one 10-year span. The amount of variability in population trends explained by soil chemistry ranged from 1.3% to 65%. Of the seven species, all exhibited at least one consistent pattern between population trend and soil chemistry, but few consistently fit all a priori predictions. The two exceptions were Swainson's Thrush from 1968-1988 and Northern Waterthrush from 1988-1998, where models explained 65% and 34% of the observed variation in population change, respectively, and relationships were in the predicted patterns. For the other species, there was no consistent evidence for soil chemistry being correlated with long-term, forest bird population changes.

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#### LEARNING SPECIFICITY IN ANTIPREDATOR TRAINING.

Captive-bred individuals that are reintroduced to the wild appear to be vulnerable to predation. There is evidence that antipredator behavior can be enhanced by pairing predator models with aversive stimuli. However, if acquired fear is not specifically evoked by the predator for which training is undertaken, it may extinguish quickly after release. We enhanced responses of tammar wallabies (*Macropus eugenii*) to a realistic model fox by pairing it with an aversive stimulus (a human who simulated a capture procedure). To determine whether the animals' acquired responses were specific to the fox, we also quantified their behavior to an array of visual models, both before and after training. Following training, animals responded to the fox by briefly increasing locomotion and maintaining sustained vigilance. Although neither had been paired with the aversive stimulus, a cat also evoked sustained vigilance, whereas a goat had no effect. These results suggest that trained animals learned that a predator-like model predicted the onset of a capture procedure. Learned response to the cat likely reflects generalization based upon convergent predator morphology. Antipredator training can thus produce a relatively specific fear response to a model predator and may improve survival after release.

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#### APPLYING THE IUCN RED LIST CRITERIA TO ISLAND SPECIES: SARDINIAN BUTTERFLIES (EUROPE, ITALY).

International nature conservation documents often reflect the celebrity of a species rather than its actual degree of threat and preference is given to more conspicuous and better studied taxa when establishing nature protection laws. We assessed the threat status of Sardinian butterfly species using the IUCN Red List Criteria. A threat factor analysis identifies potential risks towards butterflies in Sardinia arising from increasing human activities. This assessment again underlines the incompleteness of legislative conservation documents at the European scale. The Sardinian endemics *Pseudophilotes barbagiae* and *Lysandra coridon gennargentii* were identified as VULNERABLE in our analysis but are not mentioned in any European nature conservation documents. There is also evidence from many other invertebrates that priorities assigned in European nature legislation do not correspond to real threats. The inclusion of these two butterfly species in Appendix II of the Bern Convention and Annex II of the European Habitat Directive is therefore strongly recommended as well as a general update of European nature legislation.

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#### TRANSLOCATION TECHNIQUES AND STRESS LEVELS IN MAUI CREEPERS; PREPARATION FOR TRANSLOCATING THE PO'OULI.

The Po'ouli (*Melamprosops phaeosoma*) is possibly the world's rarest bird. Endemic to Maui, this honeycreeper has a population of only three wild individuals, located on Haleakala. The three individual territories do not overlap, being separated by a distance of 1-2 miles. Translocation of one Po'ouli across rugged terrain into the territory of another to form a wild breeding pair has presented a challenge to conservationists. A successful translocation will require that the amount of stress during transport be kept to a minimum, in order to optimize the chance of effective behavioral interaction upon release. We address this concern by using the non-endangered Maui Creeper as a surrogate species to explore the feasibility of hiking a Po'ouli between translocation points. We use haematologic parameters and hormone levels to test the degree of stress placed upon Maui Creepers translocated using two different transit container designs, and we incorporate radio telemetry and re-sight data to monitor post-release behavior. Clinical pathology results from Maui Creepers suggest that container design can substantially reduce stress levels during transit. Our cumulative results illustrate the feasibility of a hiked Po'ouli translocation, and indicate that monitoring stress levels in addition to post-release behavior can be a valuable interpretive tool.

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NEW PERSPECTIVES ON THE RESTORATION OF THE MAURITIUS KESTREL.

The Mauritius kestrel (*Falco punctatus*) was the world's rarest bird in 1974, when the population consisted of four wild birds, with only a single breeding pair. Habitat loss and insecticidal organochlorine use were major contributing factors to its demise. An intensive captive-breeding and reintroduction program from 1984-94 restored the free-living population to 101 monitored breeding pairs by 1998, and the current wild population continues to be monitored. The well-documented historical decline of the population, and the completeness of demographic records for the kestrels' restoration have recently offered two new perspectives on this species recovery. Firstly, an analysis of 25 years of banding records has produced demographic estimates of the severity of the population bottleneck since 1974, and provided an assessment of the effectiveness of future population monitoring on Mauritius. The findings indicate that the reintroduction program was highly instrumental in accelerating the species recovery, and provide new insight into future habitat carrying-capacity. Secondly, a molecular survey of genetic diversity across the bottleneck has enabled an evaluation of the population recovery in the light of genetic impoverishment. Together, these recent studies offer a valuable re-interpretation of previous ecological and demographic information on the Mauritius kestrel.

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ALTERNATIVE LIFE HISTORIES AND CONSERVATION BIOLOGY.

Many species have alternative life histories in which individuals of the same sex develop into different phenotypes. For example, sunfish have precocious cuckolder and adult parental males while salmon have precocious jack and adult hooknose males. Here I report on the evolutionary fitnesses of the alternative male life histories and show that, at equilibrium, the precocious males have higher average fitnesses than adult males. In addition, there is a genetic linkage between precocious maturity and fitness, thus precocious males are the reservoirs of the fittest genes in the population. This knowledge is critical for the management of wild populations and for the selection of individuals in conservation breeding. A case in point is that hatchery production of salmon typically discards jack males and uses only the hooknose phenotype as breeders. This bleeds the best genes for growth (e.g., enzymes, immunocompetence, visual and escape responses) from the population and leads to deterioration. Captive breeding programs should consider alternative phenotypes for breeders to retain the genetic health of populations, and conservation biologists should include alternative phenotypes as objectives for preservation. [Collaborator: Joe Repka, Department of Mathematics, University of Toronto.]

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A VILLAGE RANGER BASED TIGER MONITORING NETWORK THROUGHOUT THE LOWLANDS ON NEPAL.

This research assesses the extent to which tigers use land outside of protected areas as breeding or dispersal habitat. Our premise for working outside reserves is based on the following observations: (1) existing reserves are not large enough to maintain viable tiger populations, (2) extensive forest lands exist outside reserves, (3) these forest lands may serve as critical tiger habitat, and (4) local people are increasingly interested in forest restoration. Formerly, experienced biologists surveyed the area inadequately. To overcome this problem we established a network of 30 village rangers to map the location of livestock kills. The results show that tigers still disperse through even degraded habitat.

GUSTAFSON, ERIC J., and Larry A. Leefers. USDA Forest Service, North Central Research Station, Rhinelander, WI 54501, USA (EJG) and Department of Forestry, Michigan State University, East Lansing, MI 48824, USA (LAL). USING STRATEGIC MODELS TO COMPARE THE LANDSCAPE PATTERN EFFECTS OF TIMBER MANAGEMENT ALTERNATIVES.

On public and industrial timberlands, optimization models such as Spectrum often guide timber management decisions. Spectrum produces harvest schedules that are weakly spatial, yet many habitat consequences of harvest have a strong spatial component (e.g., forest interior habitat). We developed an automated procedure to simulate Spectrum harvest schedules developed for a portion of the Chequamegon-Nicolet National Forest (WI) using a spatially explicit harvest simulator (HARVEST). We used HARVEST to simulate the harvest schedules produced for the Forest Plan revision alternatives required under federal law. HARVEST produced maps of forest interior and forest edge habitat expected under each alternative, and calculated the patch structure of the resulting landscapes using seral stage to define patches. We found that the alternatives varied in their effects on landscape structure, but not as much as expected. We projected the habitat impacts of each alternative related to forest interior species, edge-dependent species, and seral stage-dependent species. Our methods provide important information needed to choose the preferred alternative for the final Forest plan.

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IDENTIFYING DPSs OF PUGET SOUND MARINE FISH: PACIFIC HAKE, WALLEYE POLLOCK AND PACIFIC COD.

In response to a petition to list 18 species of marine fish in Puget Sound, Washington under the U.S. Endangered Species Act, the National Marine Fisheries Service (NMFS) initiated separate status reviews and formed separate Biological Review Teams (BRTs) for three taxonomic groupings: rockfish, Pacific herring, and the gadiforms (Pacific hake, walleye pollock and Pacific cod). The gadiform BRT examined environmental, geologic, historic, biogeographic, life history and genetic information in the process of identifying distinct population segments (DPSs) that satisfy ESA and joint NMFS/U.S. Fish and Wildlife Service interagency policy definitions of “discreteness” and “significance”. The BRT found data on spawning aggregations, tagging, biogeography, ecological and habitat factors, seasonal migration patterns, parasite incidence, and genetic population structure to be most informative for this process. Demographic data (growth rate, age at maturity, fecundity, etc.) and morphometrics and meristics were less informative for DPS delineation. The gadiform BRT analyzed these data (within the guidelines of the joint-agency policy) and identified the following DPSs, all of which are substantially larger than Puget Sound: the Georgia Basin Pacific hake DPS, the Lower-boreal Eastern Pacific walleye pollock DPS, and a DPS for Pacific cod that extends from Puget Sound northward to at least Dixon Entrance.

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CORRIDOR USE BY DIVERSE TAXA: A COMPARATIVE SYNTHESIS FROM A LARGE-SCALE EXPERIMENT.

A number of recent studies have demonstrated that corridors influence movement rates of individual species. However, it is unclear which types of species will benefit from corridors, and which types will not. We investigated the effects of corridors on movement rates of a number of taxa, including species of butterflies, bird-dispersed plants, small mammals, and large bodied bees. Investigations of each taxa were conducted independently, but within the same experimental sites. In the experiment, large, open patches (each 1.64 ha) were surrounded by plantation pine forest. Patches varied in whether or not they were connected by an open corridor, and in their distance from each other (64 - 384 m). Habitat-restricted butterflies, bees, and plants all used corridors by moving more frequently between connected patches than between unconnected patches, or by leaving patches preferentially through corridors. A habitat generalist butterfly and two small mammals did not use corridors. Even for species that were moderately restricted in

habitat use, corridor effectiveness depended on interpatch distance relative to animal movement rates. Corridors appeared to have mainly positive and some neutral effects – but no negative effects – on plants and animals in our experiment.

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COEVOLVING METACOMMUNITY EXTINCTION PROBABILITIES: A QUANTITATIVE GENETIC MODEL. Most predictions of extinction probabilities ignore evolution and community interactions, yet recent studies document rapid evolution in some plant and animal species. Quantitative genetic recursion (QGR) models combine population dynamics with the evolution of quantitative traits (body size). I describe a QGR model of 2 prey and 1 predator populations in which parameters are size-dependent so that populations are dynamic and body sizes (parameters) coevolve in all populations. In numerical simulations without spatial structure, the presence of predation induces complex dynamics of population numbers and evolving body sizes depending on genetic heritabilities. Evolutionary dynamics vary from stable fixed points at low heritability, to regular oscillations and chaos-like dynamics at intermediate heritabilities, and back to fixed points at extremely high heritabilities. I have added to this QGR model size-dependent dispersal among metacommunities and examined a range of parameter values in which, when evolution does not occur, one or more populations either go extinct or reach extremely low numbers. When evolution is added, the range of parameters at which extinction occurs is reduced, effectively lowering the probability of extinction. These model results suggest that nature reserve designs should incorporate community interactions and the potential for evolution of ecologically relevant traits.

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SOURCE/SINK DYNAMICS IN REPRODUCTIVE SUCCESS OF AMERICAN REDSTARTS IN HABITAT ISLANDS.

Populations in fragmented landscapes may operate as metapopulations or source/sink systems. Conservation of these populations requires a knowledge of patch level reproductive success, survival and recolonization rates in order to define sources and sinks and research on the patch and landscape features that characterize source and sink patches. For 5 years I have studied American redstart reproductive success in 20 forest patches surrounded by agriculture in northern Alberta. Most patches flipped between being sources or sinks annually in an unpredictable way, but some patches were consistently sources. Contrary to predictions of island biogeography theory and many empirical studies on patch size and isolation, I found that consistent sources were smaller and more isolated than other patches and tended to have lower number of redstarts and other potential cowbird hosts in them. I suggest that cowbirds and nest predators may not enter these patches as much because of lowered profitability in finding hosts/prey.

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A BIOLOGY OF HOLOCENE PRIMATE EXTINCTION AND SURVIVAL ON THE SUNDA SHELF ISLANDS. Deeper understanding of the biology of extinction risk should help us refine conservation effort. To add to that biology, we employ the well-established method of comparing the biology of taxa that disappeared from small islands (taxa at risk) with the biology of taxa that survived on the islands (persistent taxa). The taxon investigated is the mammalian order, Primates. The islands are those created at the beginning of the Holocene as sea levels rose 120 m over the Sunda Shelf (S.E. Asia). Nine primate genera inhabit these islands, from the 40 kg orangutan, *Pongo*, to the 120 g tarsier, *Tarsius*. We use four statistical comparisons, along with phylogenetic control to ensure independence of data. As expected, large body mass, low population density, and large annual home range (high resource requirements) appear as traits of risk. Unexpectedly, neither high group mass (high resource requirements), nor low dietary variety (specialisation), nor low interbirth interval (low reproductive rate) appear as risky traits. Unexpectedly also, we identify a new trait of risk for terrestrial vertebrates, low maximum latitude (lack of adaptability?). Because different sorts of taxa are differentially prone to extinction, the community structure of small islands is substantially different from that of large islands.

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TRANSBOUNDARY RESOURCE MANAGEMENT AND THE FLATHEAD RIVER BASIN.

Historically, the successful management of natural resources across North America's borders has been complicated by a lack of coordinated conservation policies. Stakeholders in the Flathead River basin, stretching from southeastern British Columbia to northwestern Montana, are currently struggling to resolve this dilemma. Established transboundary management efforts, like the Gulf of Maine Council and the International Sonoran Desert Alliance, are tackling issues as diverse as international fishing rights and localized flood control and providing important lessons from which others can learn. Case studies of these two programs plus six others reveal a variety of successful policy frameworks and on-the-ground strategies that can inform those wishing to implement cross-border environmental management in the Flathead region and beyond. While these successful efforts share numerous characteristics, such as high degrees of stakeholder diversity and attention to ecosystem processes, they vary across their levels of institutionalization and formality. Our findings indicate that process-oriented aspects such as open channels of communication are often more critical to the effective management of shared environments than outcome-oriented legal mandates for joint protection. In general, our conclusions suggest that any thoughtful approach to transboundary resource management be rooted in certain guiding principles while simultaneously maintaining sensitivity to area-specific issues.

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#### LANDSCAPE THRESHOLDS AND NONLINEAR RESPONSES TO FRAGMENTATION BY AMERICAN MARTEN.

Marten (*Martes americana*) are regarded as a forest specialist with high susceptibility to fragmentation. Animals responding solely to direct habitat loss should exhibit linear declines as extent of unsuitable habitat increases; however, fragmentation can lead to catastrophic declines in animal populations that may be nonlinear or additive to habitat loss. Our goals were to evaluate whether marten respond to forest fragmentation and exhibit nonlinear, threshold-level declines in response to forest harvesting. Marten occupancy declined precipitously in response to an increasing percentage of unsuitable habitat (forest < 6m) in the landscape. Occupancy declined nonlinearly and approached zero near percolation (i.e., matrix fracture). We observed steep, nonlinear, threshold-level declines in occupancy by marten in response to fragmentation. Further, effects of partial harvesting in landscapes with a previous history of clearcutting were additive. Marten were virtually absent when clearcutting resulted in percolation. The decay in occupancy rate was steeper than expected based on 98 randomly simulated home ranges in areas that were not occupied by marten. Marten exhibited strong responses to forest fragmentation that must be considered across time and space. Inferred linear responses of wildlife to direct habitat loss may not be adequate to predict landscape-level responses to fragmentation.

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#### AN IDEAL FREE DISTRIBUTION BASED ON NEST SITE AVAILABILITY IN AN ENDANGERED HAWAIIAN FOREST BIRD.

The Ideal Free Distribution (IFD) can account for geographic variation in density of an organism without corresponding variation in fitness, and has the potential to be a powerful tool for biological conservation. I assessed the "habitat matching" prediction of the IFD for the maintenance of different densities of endangered Hawai'i 'Akepa, *Loxops coccineus coccineus*, within and between two nearly adjacent, 100 ha study sites in a Hawaiian rain forest. For at least the past 20 years, this insectivorous, secondary cavity nesting bird has persisted at approximately 3 times greater density at one study site than the other. Diverse aspects of forest structure, cavity availability, and home range size between the two areas were compared to evaluate the role of food and nest-site limitation to the IFD of 'Akepa. Analysis of over 7000 trees between sites revealed there were 2.94 times more potential nest-cavities available to birds at the high density site. There was little relationship between 'Akepa density and parameters known to be associated with food availability, such as tree density, basal area, canopy cover, and home-range size. Nest-cavities provided a precise habitat match with bird density and may be a strong determinant of population size in certain areas.

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#### THE ROLE OF RECOVERY PLAN REVISIONS IN MANAGING ENDANGERED SPECIES.

We utilized the database developed by a project funded by the Society for Conservation Biology, National Center for Ecological Analysis and Synthesis, and U. S. Fish and Wildlife Service (USFWS) to compare three types of recovery

plans: (1) those never revised, (2) original versions of subsequently revised plans, and (3) revised versions. Vertebrate species with designated critical habitat were nearly four times more likely to have their recovery plans revised than other species, but recovery priorities assigned by the USFWS did not appear to influence likelihood of plan revision. Paired comparisons between revised recovery plans and original versions suggested that understanding of general biology and status had improved, and that recognition of threats had increased since the original plans were drafted. However, these improvements did not appear to produce recovery criteria or monitoring actions that were more clearly justified by biological information. We recommend that recovery plan authors strive to maximize benefits from improved information in defining management actions that are more biologically justified. We also urge that USFWS establish a consistent priority system for recovery plan revisions that affords consideration to the full diversity of listed species.

HARWOOD, JOHN, and Roseline Beudels. Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LS, Scotland (JH), Institut Royal des Sciences Naturelles de Belgique, Rue Vautier 29, B-1040 Bruxelles, Belgium (RB). SPECIAL AREAS FOR CONSERVATION OF MARINE MAMMALS IN EUROPE: PURPOSE, IDENTIFICATION AND DESIGN.

Member states of the European Union are required by law to ensure the favourable conservation status of 632 species of animal and plant (including 5 predatory marine mammals – harbor porpoise *Phocoena phocoena*, bottlenose dolphin *Tursiops truncatus*, Mediterranean monk seal *Monachus monachus*, harbor seal *Phoca vitulina*, and grey seal *Halichoerus grypus*). The principal mechanism for achieving this involves the establishment of a network of Special Areas for Conservation (SACs) that protect critical habitat for each species. We will describe what we, and the European Commission, understand by “favourable conservation status”, what constitutes critical habitat for the 5 marine mammal species, how this can be identified, the processes that are involved in establishing SACs, and how SACs can be monitored to ensure that they achieve their desired purpose.

HATFIELD, JEFF S., Peter B. Sparks, Clytie Mead-Sparks, and Jack Jeffrey. USGS Patuxent Wildlife Research Center, 11510 American Holly Drive, Laurel, MD 20708-4017, USA (JSH), P.O. Box 3313, Honokaa, HI 96727, USA (PBS, CMS), and USFWS Hakalau Forest National Wildlife Refuge, 32 Kinoole Street, Suite 101, Hilo, HI 96720, USA (JJ).

GROWTH RATES OF TREES AND SHRUBS IN TWO MONTANE FORESTS ON THE ISLAND OF HAWAII. Understanding the dynamics of native Hawaiian forest is necessary for the preservation and restoration of plant and animal communities. Growth rates based upon diameter at breast height (DBH) of 2 canopy species (*Acacia koa*, *Metrosideros polymorpha*) and 11 subcanopy species (*Cheirodendron*, *Coprosma*, *Hedyotis*, *Ilex*, *Melicope*, *Myoporum*, *Myrsine*, *Styphelia*, *Vaccinium*) were measured at 6 month intervals, 1996-99, in the relatively undisturbed Kulani Forest on Mauna Loa. For comparison, growth of the canopy species was measured in a restoration area at Hakalau Forest National Wildlife Refuge on Mauna Kea, beginning in 1997. Also measured were height growth of saplings of the canopy species and trunk height of the tree fern, *Cibotium glaucum*. Repeated measures analysis of covariance was used to compare species, 6-month periods, and study sites, with growth depending on DBH or height by assuming a quadratic relationship. For most periods, growth of *A. koa* was greater than *M. polymorpha*, and growth at Hakalau was greater than Kulani. Growth of most species was lower during the 1997-99 El Niño and La Niña events, implying significant ramifications if these events increase in frequency with global warming. Data will be collected in 2001 and future years to determine if these patterns are consistent.

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A HUNTER-BASED ASSESSMENT OF THE DISTRIBUTION AND RELATIVE ABUNDANCE OF TIGERS AND THEIR PREY THROUGHOUT CAMBODIA STATUS.

Following decades of political instability, Cambodia is currently undergoing rapid development and changes in land use. Although the government made important progress protecting biodiversity on the 1990s, more accurate information is urgently needed to develop a comprehensive, landscape scale tiger conservation plan. This study surveyed 153 local hunters to determine the relative abundance of tigers and 35 other species of mammals and birds. Hunters were shown photos to insure correct identification of species. Each hunter's homerange was delineated on 1:250,000 maps. Logistic regression was used to analyze information on tiger distribution and relative abundance in relation to the relative abundance of the major prey species, vegetation type, roads and villages. Based on our analysis tigers were predicted to occur in 10 populations ranging in size 1,678-20,348 km<sup>2</sup>. A total of 68,836 km<sup>2</sup> was

considered potential breeding tiger habitat. To verify the model we have chosen the 3 best tiger areas and are conducting extensive field surveys using 30 hunters, which have been hired as permanent wildlife rangers.

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#### LOSING KEY COMPONENTS OF HAWAII'S FOREST ECOSYSTEMS: THE STATUS OF A DIVERSE GROUP OF HAWAIIAN MOTHS.

Arthropods constitute over 70% of Hawai'i's native terrestrial biota, however little effort has been directed toward their conservation. Lepidoptera represent at least one fifth of Hawai'i's terrestrial arthropods and are a key component of Hawai'i's forest ecosystems in their role as herbivores, pollinators and prey for vertebrates and parasitic hymenoptera. Recently, the U.S. Fish and Wildlife Service sponsored an evaluation of the conservation status of *Scotorythra* (Lepidoptera: Geometridae), a diverse group of endemic macrolepidoptera suspected to be experiencing population declines. Between 1996 and 2000 current populations of these moths were surveyed throughout the Hawaiian Islands, the genus was revised taxonomically, and ecological data were gathered for several species. The results of these surveys were compared with historical collections held at Bishop Museum and at The Natural History Museum in London. The results suggest that 5 species are extinct, while 3 species are extremely rare. Ecological observations show several species of *Scotorythra* to be highly specialized, feeding on a single host plant. The rarity of these species in conjunction with their ecological specialization and increasing habitat degradation renders them susceptible to extinctions. Currently, no legal protection is afforded *Scotorythra*. However, the presented data demonstrate that their conservation status merits re-evaluation.

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#### GENETIC RELATIONSHIPS AMONG MALAGASY AND MAINLAND AFRICAN NILE CROCODILES (*CROCODYLUS NILOTICUS*).

We evaluated wild populations of Nile crocodile (*Crocodylus niloticus*) from mainland Africa and Madagascar for unique molecular sequence characters in the 12s and 16s mtDNA gene regions. Historically the Malagasy crocodile was described as a distinct species, *Crocodylus madagascariensis*, found only on the island of Madagascar and the Comoros (Grandidier 1872). Subsequently, this species was synonymized with mainland African *C. niloticus*. Malagasy crocodile populations are currently managed under CITES (Appendix II) restrictions pertaining to the global Nile crocodile population. This research examines whether the current populations of *C. niloticus* persisting in Madagascar are genetically distinct from mainland Africa and from one another. The population structure and validity of species designations for Nile crocodiles are addressed. The methods developed by this project will provide the basis for a much finer approach to Nile crocodile management and conservation.

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#### ECOSYSTEMS MANAGEMENT OF THE POHAKULOA PLAIN, ISLAND OF HAWAII.

The U.S. Army continues an ecosystem-based approach to effectively manage natural resources on the 109,000-acre Pohakuloa Training Area (PTA). PTA is located in a tropical, sub-alpine, dryland ecosystem, one of the rarest of its kind on the planet. It contains three designated bird and plant preserves. Twelve federally listed plant species occur on PTA. During routine botanical surveys over the past year, new rare plant individuals and populations have been discovered at PTA. Many of those plants have been protected from ungulate browsing with temporary fences. Rare plant locations are recorded using GPS and are stored in a GIS database to provide comprehensive information regarding federally listed plants at PTA. Rare plant species are monitored on a regular basis to assess population health. Methods to revegetate denuded areas using native plants are being developed. Issues such as water and fertilizer requirements, planting techniques, species study and weed control are being tested. PTA continues to monitor and control incipient weed populations such as Russian Thistle (*Salsola kali*). During the past year, introduced predators were controlled over 70 acres of native forest bird habitat. Rodents were also controlled around rare plant species where seed depredation is a threat.

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#### INFILTRATION OF A NATIVE FOOD WEB BY BIOLOGICAL CONTROL AGENTS IN THE ALAKA`I SWAMP, KAUAI.

There exists a heated debate between conservationists and biological control workers about the extent of so-called "non-target" effects of biocontrol agents, or the rate of attack of unintended host species. To examine the impact on native Hawaiian moths by alien parasitic wasps, introduced both accidentally and as biological control agents, over two years we collected and reared over 60 species of caterpillars (Lepidoptera) from the Alaka`i Swamp, a high-elevation rain forest on the island of Kauai, that is distant both elevationally and ecologically from agricultural areas where wasps were introduced. Roughly 80% of all species of native Lepidoptera were attacked by alien wasps. The minimum parasitization rate by biological control agents was 6% in 1999 and 11% in 2000. For accidentally introduced wasps it was 2.2% and 2.6% respectively. These data indicate that biocontrol agents, introduced precisely for their aggressive attack rate, are more of a threat to native moths than accidentally introduced wasps. However, all biocontrol agents reared were introduced previous to 1950. This suggests that more recent and presumably more carefully selected biocontrol agents have been unable to invade at least the most remote native habitat on Kauai.

Hess, Steven C., PAUL C. BANKO, and Jon G. Giffin. Fish & Wildlife Management Program, Department of Ecology, 301 D Lewis Hall, Montana State University, Bozeman, MT 59717, USA (SCH), Pacific Island Ecosystems Research Center, Biological Resources Division/USGS, Kilauea Field Station, P.O. Box 44, Bldg. 344, Hawaii National Park, HI 96718, USA (PCB), Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, P.O. Box 4849, 19 E. Kawili St., Hilo, HI 96720, USA (JGG).

#### EFFECTIVENESS OF SHEEP REDUCTION OPERATIONS IN THE MAUNA KEA FOREST RESERVE, HAWAII.

Wildlife managers are frequently confronted with situations where reliable population estimates are difficult and expensive to obtain, but nonetheless important for monitoring and sound decisions. In cases where reductions or eradication of alien ungulates are conducted, removal estimators may be used to assess population size. The simplest removal estimator is based on regression of removals per event on cumulative removals. The Zippin estimator is a maximum likelihood form of the regression estimator and is available in capture-recapture programs. Both of these methods, however, may seriously underestimate population size when assumptions of demographic closure are violated. We adapted a simple population model to estimate population size of feral sheep (*Ovis aries*) and mouflon sheep (*O. musimon*) in the Mauna Kea Forest Reserve on Hawaii island. There are two forms of the model that may be applied depending on the timing of reductions relative to reproduction. The model is based on projecting the number of removal occasions until the population is effectively eliminated, and employs a polynomial equation with independent estimates of population growth rates to infer the pre-reduction population level, thus explicitly accounting for this source of demographic non-closure. We demonstrate and compare these methods of estimating population size.

HICE, CHRISTINE L. Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409, USA. MARSUPIAL COMMUNITY PATTERNS IN HUMID TROPICAL FORESTS: THE IMPACT OF HABITAT, DISTURBANCE, AND SEASON.

Marsupials constitute a large and important component of small mammal communities in humid tropical forests. However, their basic natural history and community structure are poorly understood. This paper examines basic natural history and marsupial community structure in the humid tropical forests of northeastern Peru. Comparisons of species abundance distributions indicate significant differences between disturbed and undisturbed habitats, suggesting that anthropogenic disturbance of neotropical forests can dramatically change marsupial species composition. Communities among three types of primary forest also differ in the proportion of species abundances. These changes can be explained by differences in floral and environmental characteristics, and in structural vertical complexity of the habitats. Density of marsupials varies seasonally within these habitats, with higher densities during the rainy season. However, reproductive activity is invariant across seasons. These findings have important conservation implications in the tropics, and demonstrate the need to protect mature forest if the diverse fauna present in neotropical habitats is to be preserved.

HIGGINS, KEVIN, and Michael Lynch. Ecology and Evolution, Univ. of Oregon, Eugene, OR 97403, USA (KH, ML), Dept. of Biological Sciences, Univ. of South Carolina, Columbia, SC 29208, USA (KH). METAPOPOPULATION EXTINCTION CAUSED BY MUTATION ACCUMULATION.

Theory suggests that the risk of extinction by mutation accumulation can be comparable to that by environmental stochasticity for an isolated population smaller than a few thousand individuals. Here we show that metapopulation structure, habitat loss or fragmentation and environmental stochasticity can be expected to greatly accelerate the accumulation of mildly deleterious mutations, lowering the genetic effective size to such a degree that even large metapopulations may be at risk of extinction. Because of mutation accumulation, viable metapopulations may need to be far larger and better connected than would be required under just stochastic demography.

HIRSCH, REGINA M., and Stanley A. Temple. University of Wisconsin, Madison, Department of Wildlife Ecology, 1630 Linden Drive, 226 Russell Labs, Madison, WI 53706, USA (RMH, SAT), U.S. EPA, Office of Pesticide Programs, Ariel Rios Building, 1200 Pennsylvania Ave., N.W., Washington, DC 20460, USA (RMH).

#### BUILDING A CONSORTIUM IN THE FARMING COMMUNITY TO REDUCE EFFECTS OF PESTICIDES ON WILDLIFE.

Farmers make decisions everyday during the growing season on how to control agricultural pests. However, few consider the impacts of their decisions on wildlife. Our project sought to change this by building a consortium, which included a Wisconsin farming community and wildlife ecologists. The farming community consisted of farmers, crop consultants, agriculture extension officers, IPM specialists, and Wisconsin Department of Agriculture biologists. The objectives were to understand current practices and decision-making processes by the farming community for controlling the corn rootworm and to exchange ideas of how to control this pest with minimum impact on wildlife that utilize these agricultural areas. Initial information on current practices and pesticides were obtained through a survey. Then the consortium met for a series of discussions to exchange ideas and information regarding a design and implementation of a study to assess the impacts of the current practices on an avian and amphibian species. Once current practices were assessed the consortium was briefed on the results, and additional discussions centered on alternative pesticides, application methods, and IPM methods to reduce harmful effects on wildlife. As a result of this effort, the farming community successfully implemented the selected practices to decrease pesticide exposure to wildlife.

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#### KING CANUTE AND CONSERVATION: MANAGING VEGETATION FRAGMENTS IN SALINISING LANDSCAPES.

Southwestern Australia is a recognized biodiversity hotspot with high levels of plant diversity and endemism. Extensive vegetation clearance for agriculture has resulted in a highly fragmented landscape and hydrologic changes leading to rising saline watertables. Recent research indicates that remedial actions will not be feasible everywhere and hence that much low-lying remnant vegetation is under severe threat from salinisation. What can we do about this? For high priority areas, it may be possible to implement costly preventative measures, but for many areas we need to contemplate the transition to alternative species and vegetation types. Salinisation does not occur uniformly across the landscape, and small-scale heterogeneity in topography may play an important part in maintaining patches of existing vegetation within salinising areas. We aim to provide options for maintaining existing vegetation where possible and easing the transition to alternative types elsewhere through use of more salt tolerant species. We present an interesting conundrum for conservation: faced with a massive and inevitable threat, what can we do to maintain some conservation value in an already heavily modified landscape?

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POSITIVE RESPONSE OF AN ENDANGERED SEABIRD POPULATION TO THE REMOVAL OF EXOTIC ANIMALS FROM HALEAKALA.

Exotic animals such as feral goats, feral pigs, mongooses, feral cats and rats negatively impacted natural and cultural resources at Haleakala National Park on the island of Maui. By 1987, the "crater" portion of the Park was completely enclosed by a fence to keep feral goats and pigs from entering the crater. After completion of the fence, feral goats and pigs were eradicated from the crater. The crater has been goat- and pig-free for at least 10 years. Alien predator populations (mongooses, cats and rats) have been dramatically reduced and are controlled by trapping and toxic baiting. The world's largest known nesting colony of the Hawaiian Dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*, Hawaiian name 'Ua'u) is at Haleakala Crater. This presentation examines the positive response of this endangered seabird population to the removal of these exotic animals. This presentation also examines current challenges of keeping exotic animal populations at manageable levels and ways that these challenges are overcome.

HOEBEE, SUSAN E., and Andrew G. Young. Centre for Plant Biodiversity Research, CSIRO Plant Industry, GPO Box 1600, Canberra, ACT 2601, Australia and The Department of Forestry, Australian National University, Canberra, ACT 0200, Australia (SHE, AGY).

#### CONSERVING AN ENDANGERED GREVILLEA – AN EXAMINATION OF FINE-SCALE MATING PATTERNS.

*Grevillea iaspicula* (Proteaceae) is an endangered, self-incompatible, hermaphrodite plant that is restricted to south-eastern Australia. Initial allozyme studies suggest that the populations maintain moderately high levels of genetic diversity but that paternal diversity within seed arrays is low. This work also indicates that gene flow among the populations is limited and that the populations are substantially differentiated. Microsatellite markers have allowed us to explore more directly the fine-scale mating patterns operating in these populations. Again, high levels of genetic diversity were found ( $H_o = 0.40-0.79$ ). Paternity analyses suggest that mating may not be as restricted as previously thought and that immigration could be as high as 18%. In smaller populations, plant size correlates with paternal reproductive success and, as a result, larger plants dominate within population paternity. In larger populations, more paternal plants contribute to individual seed arrays. This may be a function of stand age structure. There is some evidence of inter-specific hybridization that could threaten the integrity of the species. Given that clones have been re-introduced into some populations, these results have important implications for effective conservation of the species.

HOEKSTRA, JONATHAN M, Bill Fagan, and Jeff Bradley. Department of Zoology, University of Washington, Box 351800, Seattle, WA 98195, USA (JMH), Department of Biology, Arizona State University, Tempe, AZ 85287, USA (BF), School of Forestry, University of Washington, Seattle, WA 98195, USA (JB).

#### IS CRITICAL HABITAT REALLY CRITICAL FOR ENDANGERED SPECIES RECOVERY?

The U. S. Fish and Wildlife Service has suspended all new and proposed listing actions under the Endangered Species Act (ESA) in order to dedicate staff and funding to critical habitat designations required by recent court orders and settlement agreements. This begs the question: does critical habitat really benefit endangered species? In particular, do critical habitat designations influence recovery plans and promote improvements in species' status? No! We analyzed an extensive database on the attributes and content of 181 recovery plans, and found that recovery plans for species with designated critical habitat did not contain more detailed information about habitat requirements, were not more likely to include habitat acquisition or management among recovery tasks, and were not even more likely to include habitat considerations among criteria for measuring recovery. Furthermore, species with critical habitat were not more likely to show an improving status trend. To make designations more useful, we recommend that critical habitat be defined as a set of biological and ecological standards against which the value and restoration potential of all available habitats can be measured.

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#### SPATIAL AND TEMPORAL ANTHROPOGENIC EFFECTS ON ALBATROSS POPULATIONS AT MIDWAY ATOLL.

The impact of humans on insular avian populations within the Northwestern Hawaiian Islands has been documented since the late 1800's. Beginning in 1991, annual surveys of breeding albatross on Midway Atoll have been derived from a combination of estimates and counts. The number of Laysan Albatross nesting pairs has decreased from 429,308 (based on counts and estimates) in 1991 to 284,604 (based on counts) in 2000. The number of nesting Black-footed Albatross has shown a downward fluctuation during the past ten years. Using these nesting pair counts to document change in albatross populations, the spatial and temporal impacts of human development and restoration efforts on Midway Atoll can be quantified.

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#### ISLANDS WITHIN AN ISLAND: CONSERVATION GENETICS OF AN ENDANGERED HAWAIIAN TREE SNAIL.

The objective of this investigation was to provide resource managers with relevant data to guide conservation strategy for this endemic species. Mitochondrial DNA sequences were used to estimate genetic divergence within and among populations of *Achatinella mustelina* from throughout its range in the Wai'anae Mountains of O'ahu. Molecular genetic data were used to define evolutionarily significant units (ESUs). Hierarchical F-statistics ( $F_{ST}$ ), effective number of migrants per generation ( $N_m$ ), number of fixed differences, and uncorrected pairwise genetic distances were used and maximum parsimony and neighbor-joining trees were inferred to characterize genetic variation among 17 tree

snail populations. These genetic data support a pattern of strong population level subdivision wherein maximum genetic distances are correlated with deep, arid canyons and mountain peaks, independent of geographic distance. ESU designation was based on mean intra-population genetic divergence of less than 1.0%, a value that also corresponds to the genetic variation along ridge crests, such that populations distributed along ridges appear genetically as panmictic units. Therefore each set of populations with genetic divergence values of 1% or less was combined into a single ESU, such that the 17 populations collapsed to eight ESUs for conservation efforts including *in situ* protection and laboratory captive propagation.

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#### MONITORING THE EFFECT OF MARINE PROTECTED AREAS ON LONG-LIVED SPECIES, A CASE STUDY WITH STELLER SEA LIONS.

Slow responsiveness of population size to perturbation is a characteristic of long-lived species and presents one of the major challenges for demonstrating positive effects of management actions such as implementation of marine protected areas. In contrast, age structure can exhibit rapid shifts, and matrix models suggest that transient spikes in age-structure may be a useful tool for quickly detecting the effects of management actions. This idea was tested using Steller sea lions, a long-lived endangered otariid found throughout the north Pacific Rim. A matrix model for Steller sea lions was used to develop simple stage-ratio metrics that would be sensitive but also practical to measure in the field. Then using aerial photographs taken during population censuses between 1970-1998, these metrics were tested for their ability to detect survivorships and/or fecundity changes in the 1980s when no-entry buffer zones around sea lion rookeries were instituted and incidental takes sharply curtailed. Large transitory spikes in simple stage-ratios were detected 2-4 years after the management actions as predicted by the matrix model. This study suggests that age-structure changes can be a powerful and practical tool for monitoring the effectiveness of management actions such as marine protected areas on large long-lived marine mammals.

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#### THE USE OF HIGHER PREDATORS AS INDICATOR SPECIES: THE GULLY, A CASE STUDY.

The Gully submarine canyon off eastern Canada has recently been designated as a marine protected area (MPA), primarily due to the relatively high diversity and abundance of its cetacean fauna. Here I discuss the use of these cetaceans as indicators aiding the identification and design of boundaries for protection in this area. The use of higher predators as indicators for marine protection is attractive due to their visibility at the water's surface and thus increased accessibility to study. After correcting for search effort, cetacean distribution within the Gully was assessed relative to several spatial and temporal parameters: depth, slope, sea surface temperature and month. Species' distributions were most strongly correlated with depth suggesting that protection should be established based on bathymetric contours. However, the use of indicator species to define protected areas should not be undertaken without reference to the whole ecosystem, as boundaries defined by top predator distribution may not incorporate the spatial needs of lower trophic levels. Analysis of energy flow through the Gully ecosystem suggests that this system receives substantial spatial subsidy at lower levels. Conservation priorities for this MPA should take account of this, primarily by providing additional spatial protection in the form of buffer zones.

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#### LOCAL KNOWLEDGE AND POPULATION GROWTH IN BANGLADESH: AN OVERVIEW.

To an outsider, over population of Bangladesh has caused poverty, environmental degradation and scarcity of resources (PEDASOR). The country statistics show that Bangladesh has reduced its population growth from 3.8% to 1.8% over the last three decades. The World Bank finds that the country is still in poverty, including 30 million hardcore poor and its PEDASOR is increasing. Why? Local knowledge that includes the wisdom of the Baul philosophers suggests that Bangladesh may not yet be over populated, but the present population control policy is likely to make it so. It gives a way out to fix the population problem and PEDASOR. Based on local knowledge, this paper asserts that the impact of the current population control policy coupled with acculturation is leading the country to intellectual poverty in the future. Four socio-economic studies in village Bangladesh conducted by the author since 1987 suggest that the existing population control policy and socio-economic culture needs reformation in order to reverse the current

situation with PEDASOR. Accordingly, a three-pronged population control approach has been developed to help maintain a sustainable population growth amongst the various occupational groups. The approach includes self-reliant livelihood, optimisation of renewable resources and valuing traditional culture.

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#### PROGRESS IN SHIP RAT ERADICATION FROM ANACAPA ISLAND, CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA.

*Rattus* spp. have been introduced to 80% of island groups and are responsible for >40% of recent bird and reptile extinctions. The 13 island rat eradications in North America used a grid of bait stations refilled regularly with rodenticide bait for 1-2 years. However, on many islands, such as Anacapa Island (296 ha) where introduced *R. rattus* threaten native species including an endemic deer mouse, bait stations cannot be used due to steep topography and sensitive species. On these islands, rats can be eradicated by aerial broadcasting bait. Anacapa will be the first North American island where rats will be eradicated using an aerial broadcast. Consequently, one year was required for environmental compliance and EPA registration. In fall 2000 we did a trial aerial broadcast of 25 ppm brodifacoum spread at 15 kg/ha on a 2.5 ha test plot. All 10 radio-collared rats died and none of the 10 ear-tagged rats were recaptured post broadcast. None of the 74 ear tagged endemic deer mice were recaptured, but deer mice recolonized the test plot within 6 weeks. Eradication of rats is scheduled for Fall 2001. Planned mitigation for deer mice includes captive holding with timed release and follow up monitoring.

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#### IDENTIFYING CONSERVATION PRIORITIES: SENSITIVITIES TO MODEL SELECTION.

Conservation biologists are pressed to make recommendations about which are the most important sites to protect based on limited species distribution and abundance data. Consequently, the use of spatial models to predict potential species distributions are becoming regular tools in the conservationist's tool-box. Using eleven types of spatial models, we constructed potential distribution models for 11 species of Cotingidae (all birds of conservation concern or globally threatened) in the Atlantic forests of Brazil (one of the most endangered regions of the world). We examined the consequences of identifying priorities area (reserve network selection) based on the 11 different distribution models using complementarity rules in the WORLDMAP spatial software program. We present the data in 2 ways: near minimum set required to capture all species and near minimum set required to provide multiple representation of all taxa. From two to four areas are necessary to represent all 11 bird species in the Atlantic forests of Brazil depending on the species distribution model employed. Moreover, models differ in the number of sites available and the geographic extent from which the reserve network was selected. Thus different species distribution models provide different answers to decision-makers regarding priorities for reserve area selection.

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#### NATIONAL AND REGIONAL INSTABILITY: IMPACTS ON CONSERVATION IN LIBERIA, WEST AFRICA.

Liberia is facing economic and social crises that have had and continue to have major impacts upon biodiversity. Although the civil war (1989-1997) resulted in an apparent decline in bushmeat hunting, timber harvesting served as a major source of cash for the purchase of arms. The post-war economic crisis has left the country further dependent upon its natural resources and created a "gold-rush" climate for transnational firms, with little political will to enforce existing regulations. A recent United Nations report implicates President Charles Taylor in supporting rebel activities that are destabilizing the region. He is accused of illegal diamond trading and utilizing timber exportation by a transnational firm as a means of purchasing and importing arms for delivery to rebel forces. The involvement of the international community in the regional strife and the threat of sanctions against Liberia provide new opportunities for conservation action. Sanctions or the threat of sanctions place "the eyes of the world" on Liberia. The potential economic impact of a timber embargo provides incentives for governmental and international actions that are more related to political rather than environmental agendas, but that nonetheless may benefit biodiversity conservation in Liberia.

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**ENDANGERED SPECIES IN A BIODIVERSE WEB: CONSERVATION OF GREEN SEA TURTLE IMPACTS NATIVE EGG-EATING SNAKE.**

My research focuses on the impact of conservation practices for green sea turtle (*Chelonia mydas*) and its native egg-predator snake (*Oligodon formosanus*) in Lanyu Island, Taiwan. These lycodontine snakes are specialized for eggs of squamate reptiles by using blade-like posterior maxillary teeth to open leathery eggshell, and consume yolk. Between June and September 1997, a total of 97 snakes were recorded preying on eggs in 13 nests laid by 8 female sea turtles. The snakes were satiated before early August while the egg-laying of sea turtles peaked in late August, resulting in later broods being more successful. Conservation practices for sea turtles, such as fence protection and nest translocation, were effective in preventing nest-depredation by snakes. In addition, such nest protections also led to frequent fights while snakes competed for decreasing food supplies. A total of 16 females and 7 males were recorded with broken tails, an indication of severe physical confrontation. The breakage of tail tip peaked first in early June due to competition for scarce turtle nests, and peaked again in early August due to overwhelming competitors. Their strong competition implied that this nonlethal anti-predator project might have unforeseen ecological consequence on the snakes and other squamate species.

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**VEGETATION DYNAMICS OF COASTAL HEATHLANDS AT CAPE COD NATIONAL SEASHORE: "NATURAL" VS. CULTURAL.**

Coastal heathlands are diverse, globally-rare ecosystems dominated by low-growing ericaceous shrubs. Though heathlands represent only a small proportion of coastal uplands, they are of particular interest ecologically as they contain many habitat restricted plant and animal species. In contrast to the intensively managed European *Collina* heathlands, *Corema* heathlands in North America are rapidly disappearing; since Cape Cod National Seashore (CCNS) was established (1961), heathland acreage has diminished ca. 60% with concomitant declines in associated rare native plants. Recently, the Inventory and Monitoring Program at CCNS established permanent plots on previously sampled heathland sites, yielding a 10-year perspective on vegetation dynamics. Our surveys identified naturally-occurring heathlands as well as heathlands resulting from documented severe disturbance by humans (e.g., recent fire, grazing or land clearing), with distinct differences in species composition and abundance. Naturally-occurring heathlands were arranged along stable dunes with exposure to wind and salt spray, whereas anthropogenic heathlands were typically located inland in a patchwork of *Pinus rigida* forest. Naturally-occurring heathlands were generally stable during the 10-year interval between surveys, while succession towards forest was well under way on most anthropogenic heathlands. Our results suggest the dichotomy between "natural" vs. "cultural" landscapes may need reevaluation for realistic management of heathlands.

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**BAT AND BIRD SEED RAIN REGENERATION ON LACANDONIA TROPICAL RAIN FOREST, MEXICO.**

The Lacandonia region in the state of Chiapas, Mexico, has a serious deforestation problem and the research about the regeneration of disturbed habitats like abandoned corn fields and cattle pastures is very important for tropical rain forest conservation. It is well know the role of bats and birds seed rain in regeneration of disturbed habitats. We made an analysis of the bat and bird seed rain with seed traps placed to different distance from a forest edge, for one year we measure the seed rain abundance and diversity, and temporal patterns. We found that the distance from the forest edge has a differential effect with the habitat and disperser. We did not find differences between the number of seed dispersed by bats and birds, but we found differences in habitat and disperser on the seed diversity through Shannon Wiener Index and Greig-Smith Similarity Index. We found some differences between temporal patterns in habitat and disperser kind. Finally we found 169 species dispersed by bats, birds and wind. Bats and Birds have an important role on natural regeneration disturbed habitats of the neotropical rain forest, dispersing important pioneer species for the vegetal succession process.

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#### FACILITATION OF *CLIDEMIA HIRTA* INVASION BY AN N-FIXING TREE (*PARASERIANTHES FALCATARIA*) IN LOWLAND FORESTS OF HAWAII.

*Clidemia hirta* is a noxious weed in Hawai'i capable of rapid spread and establishment in wet forests. We investigated constraints to *C. hirta* invasion on relatively young, nitrogen-poor lava flows (200-750 YBP) in wet lowlands of eastern Hawai'i and the ways in which the N-fixing, alien tree *Paraserianthes falcataria* facilitates invasion of *C. hirta*. Where the native tree *Metrosideros polymorpha* and fern *Dicranopteris linearis* dominate these systems, *C. hirta* is infrequent. During the past 50 years, however, *P. falcataria* has spread throughout this area. Where this large tree occurs, the understory is often dominated by dense stands of *C. hirta*. Greenhouse experiments demonstrate that *C. hirta* growth is limited on young volcanic soils. Net CO<sub>2</sub> assimilation rates were substantially higher in fertilized versus unfertilized seedlings, as were mean relative growth rates (10.5 vs. 3.1 mm/mm/day). Leaf areas of fertilized seedlings were nearly three times higher than those of unfertilized seedlings. In addition, foliar N concentrations of *C. hirta* growing under *P. falcataria* were 36% higher than those growing under *Metrosideros* canopies. Results suggest that by increasing N inputs into this previously N limited system, *P. falcataria* may facilitate the spread of *C. hirta* and perhaps other invasive species as well.

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#### ELASTICITY ANALYSIS OF SEABIRD POPULATIONS: EFFECTS OF SIMPLIFICATION OF MODEL STRUCTURE.

Procelariiform seabirds are threatened by habitat destruction, introduced species, and incidental mortality in long-line fisheries. Elasticities of population growth rate can be used to compare management tactics for these populations, but must often be calculated from simplified models based on fragmentary data. Here, we report the effects on elasticity of simplifying stage-structured matrix models for the Short-tailed Shearwater (*Puffinus tenuirostris*) and the Wandering Albatross (*Diomedea exulans*). Beginning with detailed models, we progressively reduced 1) the number of pre-breeding age classes; 2) the number of breeding age classes; or 3) both. We computed population growth rate its sensitivity and elasticity from the resulting matrices. Simplification changed population growth rates only slightly; simplifying pre-breeder structure tended to increase growth rate. The results of the perturbation analyses were strikingly similar among all models; simplification of model structure did not alter rankings of the sensitivities or elasticities of population growth rate to transition elements or lower-level parameters. Our conclusion--that population growth rate and perturbation analyses of deterministic stage-structured models are robust to simplification of the number of model stages---probably also applies to other long-lived species with similar life histories (high adult survival and low fecundity).

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#### DESIGNING COARSE-FILTER METHODOLOGIES: VEGETATION VS SOILS AS PREDICTORS OF PLANT SPECIES COMPOSITION.

Maintaining biodiversity by protecting a representative array of ecosystems (often called a coarse-filter approach) requires a system of classifying ecosystems or communities that reflects species distributions. However, community composition is not stable through time because species respond to climate change individually. Because of this it has been suggested that the coarse-filter approach should be designed around physical environments--the long-term "arenas" of biodiversity--rather than ephemeral communities. To explore this idea further we sought to ascertain whether soils or overstory vegetation would be a better predictor of understory species composition in an oak-pine forest in Maine with 198 vascular species. We used simple classifications of soil drainage (poor, well, excessively) and overstory vegetation cover (mixed, coniferous, deciduous) to characterize 243 0.625 ha plots with known understory floras. Canonical correspondence analysis indicated that the soil drainage classification was a better predictor of understory composition as it explained 23.1% of the total variation while overstory vegetation explained only 15.4%.

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#### BEHAVIOR PATTERNS OF THE RETICULATE COLLARED LIZARD (*CROTAPHYTUS RETICULATUS*) IN SOUTH TEXAS.

The reticulate collared lizard (*Crotaphytus reticulatus*) is a Texas threatened species that is geographically restricted to the extremely disturbed thornscrub ecosystem of southern Texas and northeastern Mexico. Very little information exists about the basic biology of this species. Many sources anecdotally state that *C. reticulatus* is less dependent on rocky habitat than other species in the genus *Crotaphytus*, instead utilizing more brushland areas characterized by gravelly soils. The purpose of this study was to determine habitat use and behavior patterns for the species. Adult and juvenile lizards were observed in Starr County, Texas. Transects were walked during the lizards' daily activity period and microhabitat and macrohabitat use was recorded. Twenty-minute focal observations were also conducted throughout the day, recording all behavior patterns. Lizards inhabited rocky areas similar to congeners, but also utilized other microhabitats as well. They spent the majority of their active time basking for thermoregulatory purposes. A large portion of south Texas is utilized for cattle ranching, and the rocky habitat that these lizards seem to prefer is useless for grazing and often destroyed to make more suitable land for cattle. This has great conservation implications for any future management plans of this species.

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#### PELAGIC MPA DESIGN CRITERIA: OCEANOGRAPHIC AND NATURAL HISTORY CONSIDERATIONS.

Little consideration has been given to the design and implementation of open ocean reserves due to the dynamic nature of pelagic systems. Nevertheless, because many pelagic species use predictable habitats to breed and forage, Marine Protected Areas (MPAs) could be designed to protect foraging aggregations and breeding grounds. We offer a review of the major issues involved in pelagic reserve design in hopes of stimulating future discussions, research, and management actions. Reserve designs must be guided by an understanding of natural history and habitat variability. In particular, effective MPA designs must take into account the differences in scale and predictability that set aside highly dynamic pelagic systems from terrestrial and nearshore ecosystems. While traditional reserve designs may suffice to protect sessile species associated with bathymetric features, many pelagic habitats are neither fixed nor predictable. Therefore, pelagic MPAs will require new designs including dynamic boundaries defined by the extent of large-scale oceanographic features. Moreover, an understanding of the physical mechanisms that influence the formation and persistence of marine habitats will be essential to implement protected areas in the pelagic environment. In this review, we consider the following oceanographic habitats for MPA implementation: (1) static, (2) persistent, and (3) ephemeral hydrographic features.

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#### UNIVERSITY PROJECTS FOR RESEARCH AND CONSERVATION OF MARINE TURTLES IN CUBA.

Since 1997 the Center for Marine Research and the Faculty of Biology at the University of Havana have been working on a research project aimed to study and protect marine turtles in Cuba. The selected study area was the "Península de Guanahacabibes" Biosphere Reserve located in the province of Pinar del Río. Collaboration has been received from several provincial institutions, such as the Comisión para el Desarrollo Integral de Guanahacabibes, CITMA, Poder Popular Provincial, Municipio Sandino and the Ministry of Education. Up to date three working periods, from May to September, have been completed. Field trips last 15 days and students gather scientific data, such as morphometric measurements, number of nests and eggs from nesting turtles. Environmental parameters and genetic diversity have also been studied. This research has been carried out in six beaches: Antonio, el Resguardo, Perjuicio, La Barca, El Holandés and Caleta de los Piojos. Last year work on environmental education was begun in elementary schools in the study area. This project has not only increased our knowledge about turtle nesting populations, but at the same time, has elevated conscience for the conservation of this species in schools and local communities.

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#### LEMUR CONSERVATION IN SOUTHEASTERN MADAGASCAR: POPULATION ASSESSMENTS USING SURVEYS, SATELLITE IMAGERY AND G.I.S.

Successful management of animal populations is often hindered by incomplete knowledge of such basic statistics as distribution, density, and population size. The lemurs of Madagascar, despite the international attention they have received, remain poorly known outside protected areas. We use a synthetic approach combining satellite imagery and ground surveys to rank the lemurs of southeastern Madagascar based on their population size and extinction risk. First, we present new data on geographic range limits and population densities for fourteen lemur taxa derived from line-transect censuses at 15 localities. Second, satellite images are used to assess existing (1999-2000) forest cover and identify areas with high recent deforestation rates. Using GIS to overlay range limits on forest cover, a maximum extent of occurrence is calculated for each taxon. Finally, data from surveys and satellite images are combined to yield population size estimates for each taxon using two scenarios: (1) all available forest area is occupied, and (2) only protected areas are occupied. Our results suggest that four taxa exist at extremely low population sizes: *Haplemur aureus*, *H. simus*, and *Varecia variegata variegata* due to patchy distribution, and *Eulemur fulvus albocollaris* due to an extremely restricted range.

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#### PREDICTION OF THE EFFECT OF SELECTIVE LOGGING ON THE SAMBAR DEER USING SENSITIVITY ANALYSIS

The extent to which the Sambar deer (*Cervus unicolor*) population could be maintained in selectively logged forest is of primary importance. A study was conducted at Sungai Lalang Forest Reserve, Malaysia from October 1998 to May 1999, to determine the relative abundance of sambar deer in primary and logged forest and its relation to microclimate. Three compartments (C) with different logging histories (C33 and C18) and a primary forest (C24) were selected within the forest reserve. Track Identification Method was used to survey the deer along four transects at each compartment. Statistical analysis indicated that the relative abundance ( $146.53 \text{ km}^{-2}$ ) of sambar deer was significantly higher at the primary forest than that at the logged compartments ( $38.5 \text{ km}^{-2}$  and  $29.24 \text{ km}^{-2}$  for C33 and C18, respectively). Sensitivity analysis showed that the number of footprint was inversely proportional to relative humidity and directly proportional to light intensity. The study concludes that keeping big patches of primary forest within the logged forest may contribute to maintain the relative abundance of sambar deer which appeared to be sensitive to light intensity and relative humidity.

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#### LOCAL HUNTING AND "SCIENTIFIC" CONSERVATION IN SERENGETI: CHANGES IN WILDLIFE USE AND INTERACTION OF THE IKOMA.

The conservation policy in Tanzania has put much effort to restrict local hunting activity since colonial period until today. Some researches tried to seek the possibility to legalize local hunting through evaluating local hunting methods in terms of game selectivity and killing reliability. Other researches tried to estimate wildebeest utilization quota based on population dynamics influenced by rainfall. Tanzanian conservation policy still employs these "scientific" results rather than local reality in spite of its community-based advocacy. I present the change of hunting method and the human-wildlife interaction in the Ikoma society in Serengeti to examine the gap between "scientific" logic and local one. The Ikoma traditionally hunted wildlife for both subsistence and commercial use, and continue to do with innovating new hunting tools and methods even after hunting regulations strictly limited their activity in 1970's. Although those regulations resulted in people getting apart from wildlife, the wildebeest migration, passing through the Ikoma villages around Protected Areas every year, make villagers possible to experience strong human-wildlife interaction still now. This paper suggests that conservation policy makers should take account of local reliability and wildebeest migration ecology when they regulate hunting method and quota.

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#### OVERVIEW AND CONSERVATION STATUS OF HAWAIIAN ECOSYSTEMS.

The extreme isolation of the Hawaiian archipelago has fostered the development of a highly endemic flora and fauna with ancestral connections to all of the major biomes found around the Pacific rim. For nearly 70 million years the

vast expanse of the Pacific Ocean kept certain biological groups from becoming established here. Most notably absent from the native biota are terrestrial mammals, reptiles, and amphibians, as well as ants, aphids, mosquitoes, conifers, figs, and bamboos. The size and altitudinal range (over 4200 m for the highest mountains) of the islands, provide a wide variety of ecological zones, including alpine to coastal lowland habitats, across a moisture gradient that ranges from 250 to over 10,000 mm of annual rainfall. The colonization of the Hawaiian Islands, starting with the first Polynesian settlers over 1400 years ago, resulted in major changes to the native ecosystems and their associated species. Today, only about 47% of the landscape is dominated by native plant communities, and approximately 75% of the endemic terrestrial bird species and 53% of the vascular plants are extinct, endangered, or declining. Conservation efforts are focused on habitat protection, alien species prevention and control, species and habitat restoration, and public education.

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#### CONSERVING MANATEES: KNOWLEDGE, ATTITUDES AND BEHAVIORAL INTENTIONS OF FLORIDA BOATERS.

Collisions with boats account for about 25% of endangered Florida manatee (*Trichechus manatus latirostris*) deaths each year, emphasizing the need to understand the human dimensions context of manatee conservation. We surveyed 504 Florida boaters to examine their knowledge, attitudes, and behavioral intentions regarding manatee protection and management. Boaters indicated greater support for public education and speed reduction, than for more stringent regulations setting no-entry areas or wake limits. A majority of respondents believed that about a quarter of the boaters violated speed zones and entered closed areas, and perceived that almost none harassed manatees. Greater knowledge about manatees was correlated with support for their conservation. Knowledge and support were positively related to perceptions of speeding, no-entry and harassment violations. An analysis of trends in the last ten years compared our results with previous public surveys, and indicated a potential decrease in knowledge about manatees and their conservation. Based on the survey results, public communication needs were identified, to (1) fill the gaps in public knowledge about manatees and their conservation, (2) clarify speed zone regulations and harassment behaviors (3) increase public awareness of manatee conservation efforts, and (4) use mass media more effectively to increase compliance with law enforcement.

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#### BUILDING A LIFERAFT FOR *DIURIS FRAGRANTISSIMA* (ORCHIDACEAE) IN AUSTRALIA.

*Diuris fragrantissima* is an Australian terrestrial orchid species that is critically endangered because of changed land-use patterns. Only three plants remain in the wild. A co-ordinated conservation program is underway to re-introduce the species to its former range. Ex-situ plants derived from plants collected in the wild during the 1970s and 1980s form the basis of the re-introduction material. Propagation had been ad hoc with no records kept of individual crosses. Genetic and morphological analyses of ex-situ collections have identified a reasonable level of genetic diversity and the information for individual plants has been used to devise a breeding program to increase plant numbers while minimising inbreeding. Seedlings propagated in vitro are being acclimatised under nursery conditions and will be introduced into secure sites in its previous range starting in 2002. Reintroduction attempts from the 1980s were thought to have failed but a flowering plant was found in October 2000, 15 years after the reintroduction attempt and highlights the importance of longterm monitoring. It is hoped that the genetic diversity, given the limitations of the starting material, will be sufficient to ensure that a number of individuals are able to thrive and develop into sustainable populations in perpetuity.

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#### THE PALEOECOLOGY OF ENDANGERED HAWAIIAN BIRDS.

Many of Hawai'i's native birds are threatened with extinction. Two thousand years ago, these birds shared their habitats with a surprising variety of other avian species, most of which have already become extinct. Their habitats have also been depleted by population declines and extinctions of native snails, land crabs, insects, and plants. Because the ecological deterioration began prehistorically, management decisions for Hawai'i's endangered birds can benefit from insights gained through paleontological investigations. Paleodistributions provide insights into the types

of habitat occupied by endangered species when they were more widespread and abundant, as well as prior range justifications for reintroductions. Stable isotopes in bone collagen and analyses of ancient feces provide insights into former diets. With ancient DNA from subfossil bones, changes in genetic diversity that may have accompanied population decline can be traced. Paleoecology is helpful when planning habitat restoration, because it can reveal many aspects of ecosystem structure before the period of ecological deterioration. Examples of these various types of paleontological insights will be given for such endangered species as the Nene (*Branta sandvicensis*), Laysan Duck (*Anas laysanensis*), `Alala (*Corvus hawaiiensis*), Palila (*Loxioides bailleui*), and Po`o-uli (*Melamprosops phaeosoma*).

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#### EX SITU CONSERVATION AT LYON ARBORETUM.

One of the main purposes of a Botanical Garden is to preserve biological diversity. Lyon Arboretum is helping to conserve species that are in danger of extinction by preserving and propagating germplasm of endangered plant species, especially those endemic to Hawai'i. As a tropical rain forest, Lyon Arboretum offers a suitable environment for endangered species from the wet tropics, worldwide. Within this tropical rainforest, there are approximately 16,600 living accessions of plants embracing over 5,000 taxa and cultivars including endangered species represented in Amaranthaceae, Asteraceae, Camanulaceae, Fabaceae, Heliconiaceae, Malvaceae, Orchidaceae, Palmae, Sapindaceae, and Theaceae. For example, Lyon Arboretum houses one of the world's largest palm collections, some which are extremely rare in their native habitat. Lyon Arboretum also has an extensive Heliconia collection, which includes several endangered species, and has been designated a germplasm repository by the Heliconia Society International. Lyon Arboretum houses these collections on the grounds, as well as in the greenhouse and in tissue culture.

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#### MALARIA AND HAWAIIAN HONEYCREEPERS: DIAGNOSTICS AND DIVERSITY.

Introduced disease (*Plasmodium relictum*) has significantly impacted the survival and distribution of many species of Hawaiian honeycreepers. To understand why and how some species and individuals within species survive epidemics, while others succumb, requires knowledge of the complex interactions between malarial parasites and the avian immune system. Diversity of the parasite is being evaluated by SSCP analyses of rRNA and TRAP genes of the parasite. Current data suggests the presence of at least three *P. relictum* variants in the Islands. Knowledge of parasite diversity may reduce the risk of unintentional introduction of a new variant during geographic translocations or captive releases. We are evaluating host diversity at loci important in both cellular and humoral immunity (major histocompatibility complex, *Mhc*) and at the genomic level by AFLP. We have found that 'Amakihi, with a mortality rate of 60%, appear more genetically diverse than I'iwi, which have a mortality rate of >90%. Additionally, accurate diagnostics are important for the detection of (especially)chronically-infected individuals since they may have some genetic resistance to the parasite. We have developed nested-PCR diagnostic tests based on rRNA and TRAP genes, and have compared the sensitivity of these tests to that of blood smears and serological methods.

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#### OUR REAL CHALLENGE: MANAGING OURSELVES INSTEAD OF NATURE.

The stories we tell have a powerful influence on how we behave. Most stories that attempt to explain, criticize or justify the human destruction of the natural world have two things in common: our self-importance and a superficial and simplified image of who we are, thus obscuring the root causes of the current extinction crisis. Evolutionarily we are just another animal, yet our impact on the world seems undeniably disproportionate. Four factors underlie this disproportionate impact: 1) We can change our behavior and social organization to accommodate larger numbers and other changed circumstances; 2) We can develop tools that enable us to capture greater amounts of energy to feed, clothe, house increased numbers and to feed desires to accumulate wealth; 3) The biopsychological attributes that make adaptation through social and technological change possible are double-edged; and 4) Feedback loops that might alert us to the consequences of our actions are often too long for us to learn quickly enough; or those making decisions are insulated from the feed back. New stories are needed and available, but making them compelling to key constituencies had not been adequately addressed. I offer an analysis of the key elements in making new stories compelling.

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#### CHALLENGES IN ADAPTIVE MANAGEMENT OF CONSERVATION PROGRAMS: A CASE STUDY IN LAO P.D.R.

While engaged in efforts to practice adaptive management, conservation programs in developing countries are frequently implemented under conditions of limited national planning and coordination, vague and conflicting natural resource policy and unstable political environments. We conducted a case study of a conservation program in Lao P.D.R. and address the following questions: (1) How can we improve conservation success under existing sociopolitical conditions and (2) How can program evaluations be appropriately designed to maximize their effectiveness. We used the recommendations of an external evaluation and analyzed the extent to which the program was able to implement recommendations and adapt program design. Each recommendation was assigned an indicator and the presence/absence of that indicator was noted. Where absent, assumptions underlying the recommendations were tested using the constraints found to have precluded implementation. Lessons learned include the following: (1) Recognition of the overwhelming development mandate of growing economies demands flexibility in program design to achieve conservation objectives. (2) Definitions of key terms such as wildlife conservation, rural development and technical assistance diverge between host country governments and international agencies. (3) Evaluations should take into account sociopolitical realities by identifying why problems exist in program design and determine the feasibility of overcoming those problems.

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#### MODELING POLLINATOR-LIMITED PLANT METAPOPOPULATIONS: THE CASE OF THE FRINGED ORCHIDS.

Fringed orchids, a set of morphologically similar species in the genus *Platanthera*, typically exist as metapopulations associated with fragmented habitat. Reproduction depends upon pollination by specific animal vectors (usually lepidopterans), and pollinator visitation is probably often the factor limiting seed production. Within the US, several species of fringed orchids are listed as threatened or endangered at either the Federal or State level. Conservation of these species depends upon an understanding of the combined effects of fragmentation and variable reduced pollinator availability on the dynamics of local populations and regional metapopulations. We present results of a simulation model developed to represent the life history and demography of a typical fringed orchid. Pollinator limitation is modeled as an Allee effect at the level of the local population. We explore metapopulation dynamics and quantify extinction risk as a function of pollinator availability and demographic variables. Sensitivity analysis provides a measure of the relative influence of the Allee and other demographic parameters on the predicted extinction risk. We propose our modeling approach as a useful framework for evaluating the potential effects of habitat fragmentation and reduced pollinator availability in plants with specialized pollination syndromes.

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#### MONITORING THE SUSTAINABILITY OF VILLAGE CAPTURE AND TRADE OF DWARF CASSOWARY IN PAPUA NEW GUINEA.

Wildlife capture and trade for cultural ceremony and exchange in Papua New Guinea has led to extirpation of dwarf cassowary *Casuarius bennetti* in some areas and increasing pressure for trade from areas where they remain. We report on a village-based monitoring program to evaluate sustainability of wildlife capture and trade by households in the Crater Mountain Wildlife Management Area. We monitor type and number of wildlife species captured and their eventual use. For dwarf cassowary, we compared estimated annual harvest to maximum sustainable harvest, and compared change in hunter effort and catch over time. We found that capture rates of 0.06-0.07 per km<sup>2</sup> were unsustainable in one catchment and on the threshold of unsustainable use in another. Hunters from a densely populated highland sites were travelling significantly farther to encounter cassowary than hunters from lowland sites. Findings suggest that extirpation of cassowary in the management area may be avoided by restricting the method or quantity of the harvest and improving husbandry of captive birds. Results indicate that household monitoring of wildlife capture and trade is a feasible protocol for villages to implement and should be encouraged as means for communities to monitor and evaluate the sustainability of cassowary harvest.

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#### ANURANS COMMUNITIES AS INDICATORS OF STRESSORS IN AGRICULTURAL LANDSCAPES.

Much attention has been focused on potential amphibian population declines over the last decade and possible links to habitat loss and fragmentation. Relationships between anuran communities and wetland characteristics associated with particular land uses (e.g., in agricultural landscapes) and landscape metrics could lend insight into causes for or amelioration of potential stressors. We examined the relationships between amphibian communities, wetland characteristics and landscape metrics for 36 Minnesota wetlands. Anuran, vegetative and macroinvertebrate communities were surveyed at all wetlands from 1998-2000, water and soil samples also were taken for laboratory analysis. Landscape attributes were determined for concentric buffers (10 m - 100 m) from each wetland using aerial photos; broader land cover data (to 10 km) was based on satellite imagery. Anuran species richness was negatively correlated with percent of agricultural land, as was macroinvertebrate species richness. Relationships also were noted for individual anuran species and several landscape metrics. Despite negative associations between anuran species richness and wetlands in agricultural landscapes, the presence of some natural land cover, especially woodland, in the immediate vicinity of such wetlands appeared to increase their habitat value.

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#### NEEDS ASSESSMENT OF BIODIVERSITY INFORMATION USERS IN NEW YORK STATE.

Many scientists optimistically think that information about biodiversity is available and accessible to local and state decision makers and readily incorporated into decision-making. Yet this is often not the case. The American Museum of Natural History's Center for Biodiversity and Conservation initiated the New York State Biodiversity Project in part to address this issue in New York. Working in partnership with the project steering committee, the Environmental Law Institute conducted a needs assessment of decision makers in New York to identify what information is being used, its perceived adequacies, whether additional information is needed and, if so, in what format. Phone interviews were conducted with representatives from federal, state, and local agencies, the business and environmental communities, planning organizations, among others. Results indicate that most decision makers rely primarily on information from the Natural Heritage Program and state agencies, and would welcome additional data, especially if site-specific, GIS-compatible and presented electronically. The assessment highlights the need for the development of a statewide biodiversity inventory and assessment, education and outreach programs, and a central clearinghouse for biodiversity information and technical assistance. Enhancing the effectiveness of New York's biodiversity laws and policies is also important to conservation in the state.

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#### SPECIES CONCEPTS AND RARE DESERT FISHES: DETECTING A CRYPTIC SPECIES OF LEATHERSIDE CHUB.

Delineating meaningful taxonomic units remains a vexing problem in evolutionary biology with important implications for the conservation of rare species. In this study, we examine evolutionary divergence in leatherside chub (*Gila copei*), a threatened fish endemic to the Bonneville Basin and upper Snake River drainages of western North America. Using morphological, reproductive, and phylogenetic species criteria, we find that leatherside chub is actually an ancient two-species cryptic complex geographically divided into a Bonneville Basin species in the south and a Snake River / Bear River species in the north. Within each species, geographic fragmentation in the late Pleistocene accounts for genetic subdivision among populations. Phylogenetic analyses (based on mtDNA) further suggest that these two leatherside chub species are paraphyletic with respect to the geographically distant endangered Colorado River spinedaces (*Lepidomeda* species). Populations of leatherside from both species appear to be in general decline. However, our results now render the newly defined northern clade extremely rare, composed only of four known populations. Hence, immediate conservation efforts should focus on the northern species.

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#### ANNUAL POPULATION ESTIMATES OF A TROPICAL BIRD SPECIES: LESSONS IN CONFOUNDING VARIABLES.

Obtaining reliable population estimates is crucial to monitoring endangered species and developing recovery strategies. The palila (*Loxioides bailleui*) is a finch-billed Hawaiian honeycreeper found only on Mauna Kea on the island of Hawai'i. In the last 20 years over 90% of the population has become increasingly concentrated into <30 km<sup>2</sup> of sub-alpine, dry forest on the western slope. Large annual fluctuations in population estimates have been documented from surveys conducted during the non-breeding season (January-March) using the Variable Circular Plot method. While we believe that some of the variability in the estimates reflects real changes in the population, we show that much of the variation in the estimates can be linked to a breeding season that varies in length from 2-8 months. We recommend that researchers working with tropical bird species, whose breeding seasons can be highly variable, carefully select the timing of annual censuses to coincide with months that reflect the most constant range of vocalization in the target species.

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#### MEASURING HABITAT QUALITY FOR A MIGRATORY WARBLER IN NATURAL AND AGRICULTURAL AREAS IN JAMAICA.

As tropical forests are cleared, a greater proportion of migratory songbirds are forced to winter in agricultural and disturbed habitats, which, if poorer in quality than natural forests, could contribute to their population declines. We document demographic indicators of habitat quality for American Redstarts (*Setophaga ruticilla*) wintering in Jamaican citrus orchards and shade-coffee plantations, and we make comparisons with published data from four natural Jamaican habitats: mangrove, coastal scrub, coastal palm, and dry limestone forests. Although redstart density, survival (? , estimated by program MARK), and overwinter body mass retention varied significantly among habitat types, citrus and coffee values were relatively high, lying between the highest (mangrove) and lowest (dry limestone) values in natural habitats. These data suggest that citrus orchards and coffee plantations lie within the variation found among natural forests. Changes in body mass in citrus, coffee, and dry limestone forest corresponded with overwinter changes in arthropod biomass, suggesting that food availability may ultimately determine habitat quality. Density, especially in spring, was well correlated with other demographic variables, suggesting that measures of abundance may be useful indicators of habitat quality for wintering warblers.

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#### THE POPULATION STATUS OF THE MARIANA FRUIT BAT (*PTEROPUS MARIANNUS*) IN THE NORTHERN ISLANDS OF THE MARIANA ARCHIPELAGO.

Several of the remote northern islands in the Mariana archipelago were surveyed for the endemic Mariana fruit bat (*Pteropus mariannus*) between June-August 2000. Many of these islands are subjected to severe feral ungulate damage and fruit bat poaching pressure. Surveys were conducted using direct colony, evening station and evening departure counts. Fruit bat populations have declined dramatically since 1983 on the islands of Pagan and Anatahan. Evidence of fruit bat poaching was prevalent on Pagan and Anatahan. Increased feral ungulate forest degeneration was also documented. It is believed that the cumulative effects of poaching and feral ungulate destruction are largely responsible for the decline of the Mariana fruit bat population.

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#### USE OF FLUCTUATING ASYMMETRY TO ESTIMATE DEVELOPMENTAL STABILITY IN SNAKE RIVER SALMONID POPULATIONS.

Fluctuating asymmetry of meristic characters was used to evaluate possible long term effects of outplanting hatchery-reared fish on natural and wild populations. Juvenile chinook salmon and steelhead were collected in 1989 and throughout the 1990s from wild, natural, and hatchery populations in Snake River basin of Idaho, Oregon, and Washington. The experimental design involves monitoring genetic and meristic characters in yearly samples. Indices of asymmetry were developed from paired meristic characters and evaluated as indicators of developmental stability,

which has been shown to be correlated with levels of genetic/environmental variability. Lower levels of asymmetry were detected in some drainages than in others and levels were lower in steelhead than in chinook salmon. Also, some hatchery populations of chinook salmon had high levels of directional asymmetry but hatchery steelhead did not. Comparisons of these values in the two species reveal differences that may be linked to differences in hatchery management or life history. In 1994-1995 salmonids in the Snake River basin experienced a severe population crash and comparison of asymmetry levels in samples taken before and after the crash may provide insight into the genetic consequences of the bottleneck.

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#### CONSERVATION GENETICS OF WATTLED CRANES.

The Wattled Crane (*Bugeranus carunculatus*) is the largest and rarest of the six crane species in Africa. Its once vast range now consists of three disjunct populations. Most of the remaining birds occur in south-central Africa, with one small, disjunct populations in Ehiopia and another in South Africa. The objective of this study was to characterize the genetic structure of Wattled Cranes across south central Africa and assess the genetic status of the South African population. Samples from South Africa (11), Zimbabwe (12), and Botswana (3) were analyzed for variation at ten microsatellite loci and sequences of the mitochondrial DNA (mtDNA) control region. Results indicate that the Zimbabwean and Botswanan cranes are genetically similar to each other but are distinct from the South African population. Several microsatellite alleles unique to either the South African or Zimbabwe/Botswana populations were found, and of 10 mtDNA haplotypes found, only 1 was shared. Thus gene flow between these regions may have been historically limited and the populations should be considered distinct for management purposes. Further, the South African cranes show no loss of genetic diversity and translocation of new breeders into South Africa is not warranted from a genetic standpoint.

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#### LINKING HABITAT RELATIONSHIPS TO A LANDSCAPE LEVEL FOREST SIMULATION TO PREDICT FUTURE CHANGE OF FOREST BREEDING BIRDS IN THE WESTERN GREAT LAKES.

The Minnesota Forest Bird Diversity Initiative was started in 1991 to monitor populations and assess habitat relationships of forest breeding birds in northern Minnesota and northwestern Wisconsin. Here we present the initial results of our effort to develop a stochastic simulation that links the output of a landscape-level forest growth and succession model, LANDIS to habitat relationships developed for 150 species of breeding birds. We developed a set of *a priori* probabilities of the occurrence of a set of abundance categories based on our forest bird monitoring data. We tested this modeling approach in a forested area of Pine County in east-central Minnesota where we have observed a total of 75 species between 1994 and 1996. Using a 300 year simulation, the predicted number of unique species was 68, and seven of these species have never been observed during our monitoring, having range limits to either the north (6 species) or to the south (1 species). Therefore, we under-predicted the number of unique species by 12. Although there are limits to all predictive models, we believe our approach provides an unique method to explore the consequences of alternative forest management strategies on future bird communities.

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#### IT TAKES POWER TO INFLUENCE POWER: EFFECTIVE TARGETING IN THE POLICY PROCESS.

With the election of a President not noted for support of conservation it will be more important than ever for conservation scientists and advocates to be strategic in trying to influence elected and appointed policy makers. Too frequently conservationists focus on organizing groups that share their views most closely, regardless of whether or not these groups have much political clout. To maximize our ability to influence policy we need to focus on mobilizing groups that are not only likely to act in support of conservation, but who have the political resources at their behest that will make policy makers pay attention. Each situation is somewhat different, but all elected and appointed officials have constituencies that are of particular import to them. A successful strategy must incorporate how to identify those constituent groups relevant to decision makers and how to work in relation to them. By way of example, our paper will include working through a policy issue and will make specific recommendations for the most effective approach.

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#### SOCIAL AND POLITICAL ASPECTS OF EXOTIC SPECIES REMOVAL PROGRAMS.

Programs involving removal of nonnative animals from natural habitats in California frequently are challenged by local citizens or animal rights and welfare organizations. Protectors of some targeted introduced mammals--such as red foxes, feral cats, and feral goats--often appeal to news media, government officials, and the courts to leave introduced animals undisturbed on the land, or to ensure that animals would be humanely trapped and relocated to other areas or to captivity. Delay or cessation of removal projects results in increased costs of conservation programs and continued damage to native species and ecosystems. Adding to problems land managers face are mandated or illegal rescues and relocations of exotic animals, destruction of trapping equipment, intimidation of trappers, and distortion of information about the nature of the exotic animals, the seriousness of threats, and the motives of conservation groups and agencies. Endangered species in coastal habitats survive typically in remnant areas of near-natural habitat fragments that are like habitat "islands" in "seas" of developed lands. Lessons learned in recent decades from the control of nonnative animals to protect California's coastal endangered species in such habitat fragments may be helpful to managers when planning removals of exotics from islands.

KAAUMOANA, MAKAALA, and Jan M. Surface. Hanalei Heritage River, P.O. Box 1285, Hanalei, HI 96714, USA. HANAIEI RIVER HUI: A COMMUNITY MODEL FOR ASSESSING TODAY'S AHUPUA'A.

The community of Hanalei, through a series of public meetings, established the Hanalei River Hui (Hui) to coordinate local activities undertaken through the American Heritage River Initiative. The Hui strives to malama the ahupua'a (watershed) of Hanalei, guided by the Hawaiian principals of malama'aina (sustainability and stewardship), pono (integrity and balance), laulima (cooperation) and aloha, especially as it applies to cultural equity and respect. The Hui developed a list of concerns and issues within the ahupua'a and developed a watershed action plan. Keeping Hanalei River "swimable and fishable" was prioritized. A long-term ecological monitoring program (LTEMP) includes volunteer instream monitoring, larval sampling and creel surveys of the native fish, o'opu nakea. Bacteria samples were collected by community volunteers in and around the Hanalei Bay mooring area during the 2000 summer boating season to determine if there were any impacts on water quality. The Hui's water quality program also includes both regular data collection and periodic synoptic assessments to determine presence of Enterococcus bacteria in the river. Results from these three volunteer lead sampling activities will be presented along with other community lead activities within the Hanalei River ahupua'a.

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#### CONSEQUENCES OF ELEPHANT CONSERVATION IN BIODIVERSITY HOT SPOTS. THE CASE OF THE SHIMBA FORESTS, KENYA.

Because of their large size, density and habits, elephants induced habitat change can threaten endangered species conservation efforts, especially in small isolated protected areas. The Shimba Hills Ecosystem comprise isolated ancient coastal rainforest relics, and exemplify the elephant-habitat crises of the 1990's; threats caused by past management decisions that ignored the significance of the unique biodiversity found here. Of particular significance is the confinement of elephants to these habitats. This study documents the role of elephants in habitat change through aerial photograph analysis since 1956, vegetation surveys, and enclosure experiments over the last 6 years. Elephants utilize the Shimba habitats differentially, causing structural and compositional changes in the rainforest patches, and promoting secondary growth particularly in previously logged sites. Destruction is most noticeable in drier woodlands areas where bulls in particular push over trees and convert forests to bushlands. The logging of trees by elephants may be stress related. The rate of vegetation change is a function of elephant density, population structure and plant response to herbivory. The threat of elephant to these habitats is viewed in the context of management since 1900. Kenya's policy reduces management options for the 600 elephants to translocations, fertility regulation and expansion of range.

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#### SPECIES RANGES – SHOULD WE ABANDON THE DICHOTOMOUS CORE-PERIPHERY APPROACH?

The rapid decline in natural populations across the world is increasing the importance of understanding patterns of survival and extinction within species' ranges. The traditional paradigm has been that populations located in central

areas of the range will survive better than those at the periphery. Recent studies have challenged this conventional thinking, suggesting that ranges tend to collapse towards their historical peripheries rather than cores. However, these studies have used a dichotomous division of the historical range into core and periphery alone, restricting the conclusions that can be drawn. Using data for 12 mammal species, we demonstrate that when the historical range is approached more continuously, ranges do not usually contract to the very edge of the range, but rather to intermediate sub-peripheral areas located between the periphery and core. Similarly, finer sampling of a phasianid species' range has emphasized the potential importance of intermediate areas of the range in maintaining genetic and phenotypic diversity. Since conservation strategies may depend on the results of such analyses, close attention must be paid to the methods and approaches used when working within species' ranges to avoid the adoption of strategies that are underpinned by methodological artifacts, and especially by a dichotomous approach.

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#### A SPATIAL AND BIOGEOGRAPHICAL ANALYSIS OF FAUNAL DIVERSITY IN THE ANDES OF COLOMBIA.

The Andes of Colombia are physiographically complex, with three main ramifications, two large inter-Andean valleys, and several peripheral mountain ranges. This region has one of the richest biotas of the world. To understand the patterns of faunal diversification, we analyzed spatial patterns of species composition, endemism, and biogeographical relationships for rodents, bats, birds, frogs, and butterflies. All taxa showed differentiation of a Pacific slope biota with Central American relationships, and an eastern slope biota of Amazonian-South American relationships. In contrast, differentiation in the inter-Andean slopes and valleys depended on the taxonomic group. Birds had a pattern of altitudinal differentiation, with the two inter-Andean valleys forming a group of species with lowland affinities, and a highland fauna of Andean origins. On the other hand, frogs and butterflies had a pattern of horizontal differentiation, but in frogs the affinities were within mountain ranges, whereas in butterflies affinities were within valleys and adjacent slopes. These patterns are explained by the life histories of the faunal groups, and by the structural evolution of the region. Regional plans for biodiversity conservation must take into account these patterns of differentiation.

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#### NESTED SUBSETS OF SPECIES COMPOSITION: I. PATTERNS ACROSS TAXA, SPACE, TIME, AND SCALE.

As ecologists and conservation biologists, we often seek to understand how biotas and communities are organized, how they are interrelated, and how they are affected by aspects of or changes in the environment. As environmental degradation or habitat fragmentation occurs, the suitability of islands, habitats, and patches as well as the ability of individuals to move between islands, habitats, or patches is affected; this has consequences for the distribution of species across these systems. The biotas of discrete units, such as "real" islands, are easiest to compare and therefore it is not surprising that many theories of distribution, including nested subset theory, had their origin in island biogeography. However, assemblages found in habitats also can be examined for nestedness. A suite of assemblages is said to be nested if the species compositions of successively less species-rich assemblages tend to be subsets of those assemblages that are more diverse. Based on a diverse array of datasets, nested subsets were exhibited by a variety of taxa (e. g., mammals and fish) from different types of islands (e.g., real and habitat). Nested patterns suggest that the "islands" are interrelated; such patterns have implications for conservation.

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#### NESTED SUBSETS OF SPECIES COMPOSITION: II. SPATIAL AND TEMPORAL PATTERNS IN A SMALL REGION.

At the Konza Prairie Biological Station (a 3500-ha tallgrass prairie site in the Long-term Ecological Research (LTER) system), a mosaic of discrete habitats (ranging in size from 6 ha to 230 ha) has been created by different fire disturbance regimes. Distributional data have been collected across the site and through time for various taxa, including groups of vertebrates, invertebrates, and plants. These detailed data enabled us to examine assemblages of

different taxa for spatial and temporal structure within the context of a small region. We examined the relationship between assemblages found in different disturbance-mediated habitats. Our analyses were based on nested subset theory, in which a suite of assemblages is said to be nested if the species compositions of successively less species-rich assemblages tend to be subsets of those assemblages that are more diverse. For example, long-term data for small mammals (from 14 local sites over 20 years) were utilized and assemblages exhibited a high degree of nestedness in space and time. This was true for individual years and sites, as well as for the entire study area and period. This suggests that movements between the habitat islands are important for maintenance of the overall fauna.

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#### GAP ANALYSIS IN KANSAS: NEW INNOVATIONS FROM KS-GAP.

Numbers of threatened and endangered species in the United States continue to increase. A national effort [Gap Analysis Program (GAP)] is underway at the state-level to document which species are protected on public lands. Each state develops GIS layers for land cover, predicted distributions of terrestrial vertebrates, and stewardship. It is challenging to develop techniques that work on all layers across the U.S. The Kansas GAP project (KS-GAP) used plant phenology (multi-dates of satellite scenes) to map vegetation at the alliance level. Detailed land cover data are required to predict vertebrate distributions based on habitat associations. The challenge for the vertebrate layer is to digest large volumes of literature both efficiently and consistently. KS-GAP has developed a relational database/decision support system and an on-line reviewer system, which largely automates the process. The challenge of the stewardship layer is to assign conservation status to each land unit to conduct a gap analysis for each vertebrate species. KS-GAP has developed a survey to assist in determining any legal mandates and types and intensity of usage of lands relative to conservation status. All of these tools can be adapted to work across the U.S. for applications to conservation issues.

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#### DIFFERENTIAL PREDATION ON TWO SPECIES OF CO-OCCURRING GROUND-NESTING BIRDS IN NEW ZEALAND.

The banded dotterel and black-fronted tern are two endemic bird species that share the same braided river habitat of the Mackenzie Basin, South Island, New Zealand. Banded dotterels are common, solitary nesters and black-fronted terns are rare and declining colonial nesters. I tested the hypothesis that the two species are affected differently by predation pressure by monitoring banded dotterel (n= 360 nests) and black-fronted tern (n= 623 nests) breeding success in the Ohau river over three years, 1998-2000. Video cameras, radio-transmitters and other observations showed that introduced mammalian predators were the main cause of mortality for eggs and chicks of both species. Breeding success varied between years, but in any given season, banded dotterel egg survival (67.4%) and chick survival (48.5%) was higher than that for black-fronted terns (eggs 45.0%, chicks 29.5%). In at least 10 tern colonies, I found evidence that a predator(s) discovered the colony partway through the breeding season and systematically destroyed or ate all remaining eggs and chicks, which partially explains the lowered breeding success of black-fronted terns. This study provides evidence that birds nesting in colonies are more vulnerable to predation by introduced predators than are solitary-nesting birds, in the braided river environment.

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#### AFFORESTATION AND NATURAL REGENERATION IN FORESTED WETLANDS OF THE LOWER MISSISSIPPI VALLEY.

Conversion has resulted in the loss of over 80% of the historic bottomland hardwood forests of the Lower Mississippi Valley. Past efforts and current interests in afforestation emphasizes the need for more information concerning the success of different planting techniques as well as subsequent natural woody regeneration. We studied oak survival/growth and natural invasion on 14 planting treatments (combinations of no till, strip disking, double disking, rolling, maximerge direct seeding, cyclone direct seeding, and bare-root planting) at four locations in Louisiana. After the sixth growing season (fall 1999) 16,511 saplings of thirty four woody species were identified, giving an overall average of 697 oaks and 941 invaders (greater than 30 cm tall) per hectare. Significant effects of planting techniques

and distance to forest were detected. More elm, ash, red maple, box elder and sugarberry were found on the no-till and strip disked sites while the planted oaks were more numerous on the disked sites. Natural regeneration declined with distance from the nearest forest edge, yet some invaders were found at distances greater than 850 m. This study shows that the woody diversity of planted sites may be enhanced through strip disking or no-till on some portions of the site.

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#### SCALE-SENSITIVITY OF RANGE ESTIMATES IN THREAT ASSESSMENT: A CONTRIBUTION FROM THE NCEAS EXTINCTION RISK PROJECT.

Threat assessment protocols (e.g. IUCN Red List criteria) use estimates of species' range to assess relative risks of extinction. The protocols compare range size, estimated from the number of occupied map grids, with threshold values that determine scores or categories of risk. We examined scale dependency of range estimates by applying fractal analysis to simulated and real species. The simulated ranges sampled variation in number, extent and spacing of occurrences. The real species were threatened Australian plants. Range estimates were positively related to the spatial scale at which they were estimated, but the slope of the relationship varied with pattern of clustering. Thus, outcomes of risk assessment may be biased by the choice of scale for range measurement because fine-scale estimates will rarely exceed thresholds resulting in a high-risk outcome, while reverse is true when coarse-scale estimates are used. To reduce these artefacts, we propose simple standardisation procedures using linear scale-area relationships that intersect range thresholds at a standard scale. The procedure ignores complex variation found in some real scale-area curves, but should yield more reliable risk assessments than if scale-dependence is ignored. It is also sufficiently simple to accommodate limited information and the varied skill levels of protocol users.

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#### BIRDS ARE NOT FISH: DEMOGRAPHIC VARIATION IN AVIAN CLUTCH SIZE IS NOT POISSON-DISTRIBUTED

Population viability analysis requires that a stochastic model be specified to describe "demographic stochasticity," the uncorrelated variation among individuals in demographic performance. Many PVAs use the Poisson distribution (for which the variance equals the mean) to model fecundity. This model assumes that the probability (per unit time) of laying an egg is independent of the bird's reproductive history. We fit a variety of discrete probability distributions to bird clutch size data from 47 populations of 20 species. The Poisson distribution almost never fit well. A given dataset was often fit equally well by several distributions, but the distribution that consistently fit well across nearly all datasets was the "generalized Poisson," a two-parameter extension of the Poisson distribution. This distribution can be interpreted as representing a process in which the probability per unit time of laying an egg depends on the number of eggs already laid. Thus, the generalized Poisson model has stronger conceptual and empirical support than the Poisson model for describing clutch size variability. Furthermore, the estimated variance was always less than the mean, suggesting that many birds may have a lower extinction risk than would be projected by PVA models that use the Poisson distribution.

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#### COMPARISON OF VOLUNTEER HUNTERS *VERSUS* STAFF CONTROL OF FERAL UNGULATES IN PROTECTED AREAS OF MOLOKA'I, HAWAII.

Results of scientific research on feral animals in the 1970's and 1980's were so overwhelmingly conclusive concerning the negative impact of feral ungulates on native ecosystems that the main question remaining was how to cheaply and effectively remove the animals from conservation areas. This study compares the cost efficiency of a volunteer hunting program for feral ungulates *versus* an aerial shoot/snaring program in the native ecosystems of Moloka'i, Hawai'i. The primary goal of this research was to 1) test if volunteer hunters were able to keep animal activity to levels that had been achieved through the combination of aerial shooting and snaring and 2) keep costs at or below the aerial shoot/snaring program. The test area included Hawai'i's Puu Alii and Olokui Natural Area Reserves (NAR), parts of Kalaupapa National Historical Park, and Hawai'i's Natural Area Partnership Program (NAPP)/The Nature

Conservancy's Pelekunu and Kamakou Preserves. This study shows that public or volunteer hunting is not as effective in controlling feral pigs in remote areas as staff control but can be effective in more accessible conservation areas.

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#### PATTERNS AND CAUSES OF SPECIES ENDANGERMENT IN CANADA.

Regional patterns of species at risk of extinction are poorly studied in Canada. Instead, conservation initiatives more commonly focus on single-species investigations. While these are invaluable components of an integrated conservation strategy, they provide little guidance on the causes of species endangerment nor do they suggest avenues for reducing the risk of extinctions in general. I compiled digital range maps of every species at risk of extinction in Canada. I then collected several measurements of environmental factors that should influence endangered species density. These included land cover (derived from SPOT-VGT imagery for 1998), land use intensity (including data on regional applications of herbicides, pesticides, and fertilizers), primary productivity, evapotranspiration, temperature, precipitation, and the extent of Canadian protected areas. All data were assembled and analyzed in ArcInfo GRID and Systat. Endangered species densities are highest in southern regions in Ontario, British Columbia, and the prairies. High intensity agriculture dominates these areas: this factor emerges as a primary cause of biodiversity decline in Canada. Climate's role in determining numbers of species at risk in Canada is secondary but significant and there is little effect of protected areas on endangered species density.

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#### THE RIVER CONTINUUM CONCEPT: DOES IT APPLY TO HAWAIIAN STREAMS?

The River Continuum Concept (RCC) has provided a unifying watershed-scale framework about the functioning of flowing water ecosystems for over two decades. Although modified to increase its utility as a general theory, the RCC has met with only limited success in predicting biological changes in North American rivers. Using biomonitoring data collected in an LTER Project in Limahuli Stream on Kaua'i, predictions of functional attributes based on RCC theory were tested to evaluate its applicability. RCC patterns did not match observed relative riparian canopy coverages, location and variability in organic matter inputs and transport, shifts in invertebrate functional groups, and attributes of primary/secondary production along the stream continuum. Low order, high gradient, flashy Hawaiian streams apparently do not fit the physical template of the continentally-derived RCC. Functional processes in Limahuli Stream were driven by the dense, excessively closed alien riparian canopy which limited instream autotrophy and pulsed large quantities of organic litter through the continuum. The RCC may prove to be better suited to higher-ordered, less canopied Hawaiian streams that flow into the ocean through deep estuaries. While structure / function in Hawaiian streams may depart from idealized RCC patterns, the theory provides a useful approach for comparisons.

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#### THE MAKUA IMPLEMENTATION PLAN: A COMPREHENSIVE SPECIES AND HABITAT CONSERVATION PROGRAM.

As a result of Section 7 consultation with the U.S. Fish and Wildlife Service, the Army identified 29 endangered plants and 1 endangered snail that require stabilization to avoid being jeopardized by routine military training at Makua Military Reservation (MMR), located on the northwestern side of O`ahu. These species have significant portions of their known distribution on the MMR or adjacent lands that comprise the Makua Action Area. The Army established a team of agency representatives, adjacent landowner representatives, and biological experts to help design and oversee the writing of a plan to stabilize all of the affected species so military training could resume. This team met over fifty times during the past two years to draft the Makua Implementation Plan (IP). The process of developing the IP involved detailed research and discussions addressing many areas of species conservation including definition of a population unit and what constitutes stability of a species; the role of *in situ* and *ex situ* management actions; population maintenance, augmentation, and reintroduction; alien species management and habitat restoration; as well as developing reintroduction standards and guidelines that address population genetics and preventing alien pathogens from being dispersed as a result of species reintroductions.

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#### FOREST LOSS IN A SUMATRAN LANDSCAPE AND THE SIGNIFICANCE FOR CHARISMATIC MEGAFUNA.

Given current rates of deforestation on the Indonesian island of Sumatra (558,000 ha/yr since 1985) lowland forest could disappear within 5 years. We examined trends in deforestation in Bukit Barisan Selatan National Park (BBSNP), Sumatra's third largest protected area (3,568 km<sup>2</sup>), and evaluated the impact of forest loss on elephants, tigers, rhinos' and tapir. We used GIS to examine changes in 6 landuse classifications by slope and elevation for the southern 70% of BBSNP and a 10-km buffer zone between 1985, 1989, 1994, 1997, and 1999. We estimated relative abundance of mammals using camera traps and calculated distance to 1999 forest edge and park boundaries for target species. BBSNP lost 661 km<sup>2</sup> (28% sample) between 1985-1999 at a rate of 2%/yr. Only 40 km<sup>2</sup> remain forested in the surrounding buffer with 96% of the land in agriculture. Forest loss was significantly higher at low elevations (<500m) and on gentle slopes (<10°). Forest edge did not extend beyond park boundaries and was often 1-2 kms within boundaries. Tigers, elephants and rhinoceros tended to avoid forest edge while tapir did not. Projection of current trends suggest that BBSNP may become too narrow and fragmented to support ecologically functioning populations of large mammals.

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#### FLOW AND ECOSYSTEM PROCESSES IN HAWAIIAN STREAMS.

Stream flow dynamics result from a complex interplay of local geology, hydrology and climate. Embedded in this physical framework are biological processes, influenced by stream flow dynamics, but also by evolution, ecology and biogeography. In Hawaiian streams today this complex system is further altered by anthropogenic activities including changing land use patterns, water removal, channelization, and introduction of alien species. We are faced with choices regarding watersheds and their streams. The value of developed land and water can conflict with the value of natural systems. We are only beginning to see how these complex systems function, but such information is vital to making informed decisions. We synthesize results from studies that have begun unraveling the web of interconnections among physical and biological factors. Temporal changes have strong influences on chemical and biological processes in streams. Some of these changes are sporadic and hard to predict, but others are patterned; though the patterns themselves are complex; influenced by local conditions and large-scale climatic events. Biological functions in the Hawaiian streams we studied are dominated by flow conditions, and the major players in biological processes today are alien species, both in the riparian zone and the stream itself.

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#### WINTER MORTALITY OF DEER IN A FRAGMENTED ISLAND ECOSYSTEM.

Sitka black-tailed deer (*odocoileus hemionus sitkensis*) mortality transects have been conducted in the spring along the beaches of southeast alaska since the early 1960's, primarily as an index of winter mortality. Old-growth forest patches, or islands, adjacent to the beach provide critical low elevation winter habitat for deer. Forested islands are situated among a complex mosaic of muskegs and meadows, which is further fragmented by clearcuts. We evaluated the relationship between natural deer mortality and forest characteristics (e.g. Forest cover, seral stage) by delineating habitat patches based on landscape features, winter home range estimates and seasonal use patterns. Preliminary analyses explored the relationship between carcass density and forest cover, weather variables, and estimated deer abundance. Temperature had the greatest influence on carcass density ( $p < 0.001$ ); as temperature decreased carcass density increased. Additional landscape metrics including patch size, shape and insularity were calculated to evaluate the degree of fragmentation within the habitat patch. These metrics are used to make management recommendations for the retention of forest buffers to minimize further fragmentation and effects of timber harvesting on deer.

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#### ABUNDANCE AND DEMOGRAPHY OF THE ENDANGERED HAWAIIAN HAWK: IS DELISTING WARRANTED?

To provide the U.S. Fish and Wildlife Service with updated information on the Hawaiian hawk ('io, *Buteo solitarius*) for reconsideration of its current status (endangered), we determined population size, distribution, habitat availability, survival, fecundity, and finite rate of increase ( $\lambda$ ) of 'io during 1998 and 1999 on the island of Hawai'i. We estimated the total population at 1,457  $\pm$  176.3 SE hawks. First year and adult survival was 0.50  $\pm$  0.10 and 0.94  $\pm$  0.04, respectively and fecundity was 0.23  $\pm$  0.04 female young/breeding female.  $\lambda$  was 1.032  $\pm$  0.043. The population appears viable based on current 'io populations that are equal or larger in size to estimated populations prior to human contact,  $\lambda \sim 1$ , and high adult survival. Additionally, substantial areas of habitat are protected, 'io appear resistant to avian diseases found on the island, there is no evidence of negative impacts from contaminants, and the bird's show the ability to use human-altered landscapes and exotic prey. However, because of the short duration of this study, the relatively low population size found on only one island, the variance around our estimates, and environmental stochasticity, we feel delisting is not warranted, but instead recommend downlisting to threatened status.

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#### FACTORS AFFECTING THE DISTRIBUTION OF FOUR TAXONOMIC GROUPS ON SMALL TROPICAL ISLANDS.

Tropical islands within Southeast Asia are increasingly being developed for ecotourism, a trend that is likely to continue. It is critical from a conservation perspective to determine the factors affecting the distribution of island biotas in this region. We assessed the roles of biogeographic and environmental factors affecting the distribution of vascular plants, butterflies, springtails and birds on 17 tropical islands of varying sizes in Singapore. Area was the most important factor in determining the distribution of butterflies and springtails. Environmental factors had no significant effect on the distribution of butterflies and springtails. The distribution of plants was apparently unrelated to any of the biogeographic and environmental factors examined. Bird data are still being analyzed. Butterfly, springtail and plant communities on the islands were highly nested. Individual butterfly species and springtail genera showed disparate responses to the biogeographic factors. Conservation strategies must take into consideration how target taxa respond to biogeographic factors, instead of relying on general principles. The strong area effect and highly nested patterns in the distribution of the three taxonomic groups indicate that larger islands should have the highest conservation priority as they have higher numbers of species, many of which are absent on smaller islands.

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#### EFFECTS OF HABITAT SIZE AND ISOLATION ON OCCURRENCE OF DOLLY VARDEN (SALMONIDAE; *SALVELINUS MALMA*).

The concepts of extinction-(re)colonization dynamics applies to naturally or artificially fragmented populations. We investigated the effects of habitat size and isolation (distance to nearest occupied habitat) on the patterns of presence or absence (occurrence) of patchily distributed stream-dwelling Dolly Varden in individual tributaries. We predicted that the probability of occurrence would 1) increase with habitat size because of low extinction rates in large habitats and 2) decrease with increasing distance among habitats because of low recolonization rates in isolated habitats. Our first prediction was supported by a logistic regression of Dolly Varden occurrence on habitat size, indicating that small populations may be especially prone to extinction. Oppositely, distance to nearest population did not affect Dolly Varden occurrence. This suggests that colonization of unoccupied habitats was rare and independent of geographic distance, and that extinction rates may exceed recolonization rates. However, a previous genetic study revealed isolation by distance, a pattern inconsistent with the present results. This discrepancy may result from the limited available information on temporal fluctuations of occurrence and deserves further attention.

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#### POPULATION GENETICS OF BURROWING OWL: WHAT ARE THE EFFECTS OF PUTATIVE PHILOPATRY?

Traditional mark-recapture studies suggest that burrowing owls (*Athene cunicularia*) have a high degree of natal and breeding site philopatry, which may result in significant genetic differentiation of populations. Low levels of gene flow among populations would make populations more susceptible to local extirpation, an important concern given the declining status of burrowing owls across much of their range. We examined 10 polymorphic microsatellite loci to assess population genetic differentiation of Wyoming ( $N=3$ ), California ( $N=3$ ), Idaho ( $N=2$ ), and Utah ( $N=1$ ) populations. Population sizes ranged from 10-35 individuals (except Utah, which had 5 individuals). Average  $H_e$  was 0.65 (0.20-0.85) and number of alleles/locus ranged from 3 to 15.  $F_{ST}$  and  $F_{IS}$  values were 0.010 (95% CI, 0.003-0.019) and 0.011 (95% CI, -0.021-0.023), respectively. Pairwise C<sub>vali</sub>-Sforza (C-S) genetic distances were low (0.024-0.051) and did not correlate with geographic distances. Likewise, a UPGMA consensus tree using C-S distances did not group populations in a biologically meaningful way, suggesting that the study populations were essentially panmictic. Contrary to mark-recapture studies, our results suggest that gene flow among populations is significant, even in more philopatric resident populations. Long distance dispersal events, which are difficult to observe in the field, may be responsible for panmixia.

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#### POPULATION ASSESSMENT OF GUNTHER'S GECKO IN ITS NATURAL HABITAT, ROUND ISLAND, MAURITIUS.

A morphometric and microhabitat analysis was performed in 1999 on the only wild Gunther's Gecko (*Phelsuma guentheri*) population. A total of 33 individuals were encountered, with 3.26 specimens per person per hour. Habitats occurring on the 150 ha island were classified according to their suitability for the geckos: (1) Unsuitable: with no vegetation, (2) Suboptimal: with scarce vegetation, and (3) Optimal: with almost continuous plant cover. Number of geckos per hectare was 0.1, 10, and 100 in the unsuitable, suboptimal and optimal habitats, respectively, with these extending over 65%, 10% and 25% of the island's territory. Total population was estimated as 4430 (cf. 3426 in 1996). Daily pattern of temperature and humidity were recorded in a *Pandanus vandermeerschii* canopy, a characteristic microhabitat. Both temperature and morphological data from the examined specimens were compared to a data set collected previously in captive geckos and their artificial environment at the Jersey Wildlife Preservation Trust. The temperature trend of the wild microhabitat ran higher than the curve reflecting captive conditions. Morphological comparison (SVL, body weight) suggested that wild geckos are less corpulent than those born in captivity. The occurrence rate – hence population size – of Gunther's Geckos is slowly increasing on Round Island.

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#### DO INVASIVE PLANT SPECIES OVERCOME THE MYCORRHIZAL BARRIER THAT LIMITS RECRUITMENT OF NATIVE SPECIES?

Poor recruitment of Hawaiian plant species in disturbed habitats appears to be related to sub-critical populations of symbiotic arbuscular mycorrhizal fungi (AMF) in soils. In contrast, invasive species possess two mechanisms that allow them to grow well in soils in which AMF population is so low that native species fail to establish. The first mechanism is the ability of roots to become heavily colonized by AMF when the population of the fungi in the soil is low. In such soils roots of native species are unable to become colonized or are colonized so slightly that no significant benefits result. The second mechanism, seen in some invasive grasses, is the high efficiency in P-uptake in the absence of AMF. Such species are capable of invading areas where AMF are absent (e.g., highly disturbed or barren sites). Because an estimated 90% of Hawaiian species require AMF in native sites, their ability to compete with invasive species can be reduced significantly by any factor that lowers AMF populations in soil. Results from several experiments indicate that successful restorations will require that an adequate population of AMF is present at the site or is added to the site during outplanting.

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#### THE LAYSAN DUCK (*ANAS LAYSANENSIS*) IN CAPTIVITY.

The Laysan Duck (*Anas laysanensis*), currently found only on Laysan Island, is one of the most highly threatened of birds. Information on the species in captivity is essential for effective conservation planning. Individual Laysan

Ducks were first removed from Laysan in 1957 to establish a captive flock. We sent a questionnaire to 46 facilities and individuals holding Laysan Ducks in 1999 to collect information on their current status in captivity. There are currently 211 captive Laysan Ducks among 32 facilities in the US and internationally, none of those in Hawai'i. All captive flocks descended from fewer than 19 founding pairs removed from Laysan Island in 1957-58 and 1978. Survey results suggest that the species initially bred well in captivity, but that inbreeding depression may be a problem today. Poor breeding was reported by most of the respondents. Hybridization was reported as uncommon despite being kept in facilities with mixed species. The captive propagation program was proposed as a back-up in case of natural disaster on Laysan Island. However, genetic adaptation to captivity, disease risks, inbreeding depression, and the scattered location of existing captive birds indicate that current birds in captivity are unsuitable for reintroduction to Laysan Island or other islands.

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#### BEHAVIORAL PROFILES OF THE CAPTIVE WHOOPING CRANE AS AN INDICATOR OF REINTRODUCTION SURVIVAL.

Predation by bobcats (*Lynx rufus*) has been the greatest cause of mortality in the program to establish a population of nonmigratory whooping cranes (*Grus americana*) in Florida from captive-reared birds. This study investigated whether the behavior, in captivity and shortly after release, of juvenile cranes can be used to predict their survival in the wild. Two annual cycles of whooping cranes produced at the USGS Patuxent Wildlife Research Center during 1998-1999 were observed in captivity from hatching to 20 weeks of age. Several weeks of post-release behavioral data were collected in Florida during 1999-2000, and mortality data were collected at least twelve months post release. Behavioral repertoires of individual birds were produced and compared using repeated measures ANOVA to test for differences among individuals, rearing treatments, and other factors. Rearing treatments were parent reared, hand reared, and hand reared with exercise, but rearing treatment and year were not related to survival. Stepwise logistic regression was used to develop a model showing that survival in Florida was associated with foraging and walking in captivity, and body weight at release. Behavioral modification of birds produced in the future may improve the chances that a reintroduced crane will survive the critical first year.

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#### FROM FLORAS TO ECOREGIONS: PLANT RICHNESS AND ENDEMISM IN THE INDO-PACIFIC.

As a first step in preserving global biodiversity, areas must be prioritized to species richness, endemism, rarity and habitat loss. Ecoregion units are large areas of land or water delineated by environmental conditions and natural biotic communities. Distributions of birds, mammals, reptiles, and amphibians have been analyzed at global and continental scales to identify high priority ecoregions for conservation. Integrating plant biodiversity into these results, however, is a challenge, as approximately 300,000 flowering plant species exist in the world today. Using records of ecological characteristics and species distributions from floras and monographs, we mapped out all species of a diverse set of families to each ecoregion in the Indo-Pacific. Species richness and endemism were calculated for each ecoregion. The ecoregions with the highest combined number of plant species are the lowland rain forests of Borneo, Peninsular Malaysia and Sumatra. The ecoregions with the highest number of endemic species are the lowland rain forests of Borneo, Peninsular Malaysia and Luzon, and the montane rain forests of New Guinea's Central Range. There is little congruity among families (no single ecoregion is rich in all families), highlighting the importance of choosing the appropriate taxon when assessing biodiversity richness and selecting priorities among ecoregions.

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#### MARbled MURRELET DECLINES IN ALASKA AND THE ROLE OF BREEDING SUCCESS AND FOOD.

Marbled murrelets are non-colonial and can use small patches of fish, thus their breeding success should be less vulnerable to fluctuations in food than that of other seabirds. Harvest of forest nesting habitat in Prince William Sound (PWS), Alaska has been negligible, yet the murrelet population there has declined. To examine the role of food we

surveyed murrelets at sea during summers of 1994-99, in conjunction with aerial surveys of forage fish. We surveyed 2- 6 Sites/year (~ 50 km shoreline each) and calculated fish school density within average murrelet foraging range (16 km radius/ Site). Murrelet productivity often tracked annual fish abundance, but Site effects were greater, and were consistent. Juvenile murrelet densities were highest where fish were present early and >1 species available. Juvenile murrelet density declined coincident with the annual decline in adults at a Site. The ratio of juveniles:adults did not decline, suggesting that lower breeding success was not the problem. Although fish abundance was spatially linked to murrelet productivity, we suggest that the decline in murrelets in PWS as a whole is due to loss of adults. Potential factors could be insufficient food during breeding to maintain adult weight, insufficient food during winter, or anthropogenic mortality factors.

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#### CONSERVATION OF *ASTER KANTOENSIS* AND ITS SEED EATER, ENDANGERED LOCAL ENDEMIC.

*Aster kantoensis*, a monocarpic perennial herb belonging to the Compositae, is an endemic on the gravelly floodplains of the Tama and two other rivers in Japan. The number of the flowering plants on the Tama floodplain decreased from 45,000 in 1991 to 650 in 2000. Larva of *Coleophora* sp. eats its achenes. It is regarded as one of the factors causing the decline of the plant (Inoue et al., 1998). We conducted a five-year survey from 1996 to make clear the relations between them. The number of the flowering plants on the Tama floodplain was recorded in November and that of the larvae on their heads in January the following year. No larva was observed in 89% small isolated subpopulations with less than 10 flowering plants. *Coleophora* larva is apparently depending only on *A. kantoensis*, so there is a risk of its extinction before *A. kantoensis* goes out of existence. It should be urged to consider measures to conserve *Coleophora* larva as well as *A. kantoensis*, such as preservation of the two existing large subpopulations at Akiruno and introduction of some *Coleophora* larvae into an *A. kantoensis* patch near Akiruno planted by a local nature conservation group.

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#### DIFFERENCES IN NECTAR-ROBBING BEHAVIOR BETWEEN TWO INVASIVE ANTS.

Invasive ants are considered among the greatest threats to Hawai'i's native flora and fauna. As part of an experiment to test the impact of ants on o'hia (*Metrosideros polymorpha*) pollination, I compared the behavior of big-headed ants (*Pheidole megacephala*) and Argentine ants (*Linepithema humile*) on o'hia flowerheads. I observed selected flowerheads in bloom on 10-12 trees in each of two sites with *L. humile* and two with *P. megacephala* in June-July 2000. I determined the amount of nectar taken per ant by comparing weights of empty and full ants collected as they entered and exited o'hia flowerheads. At a subset of flowerheads, I used a capillary tube to imitate a floral visitor. The mean proportion of observations of flowerheads with *L. humile* was greater than the mean proportion with *P. megacephala* ( $p < .05$ ), but there was no difference in proportion of flowerheads discovered, or in the mean number of ants that recruited to the flowerheads. *L. humile* collected on average 2.1 times as much nectar as *P. megacephala*, and was more likely to attack the "floral visitor" ( $p < .01$ ). Though both species utilize o'hia nectar, Argentine ants are more likely to have an impact on other visitors to o'hia flowers.

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#### WHAT DO WE KNOW, AND WHAT DON'T WE KNOW, ABOUT INBREEDING DEPRESSION?

The average depression in fitness of inbred organisms was documented extensively by Darwin and many since. Yet the effects that inbreeding has on viability of populations depends critically on the nature of the genes that cause inbreeding depression, the distribution of deleterious alleles within and between populations, and the interaction of genetic effects with environmental conditions. Only recently have studies explored the nature, extent, consistency, and context of inbreeding depression. I will review recent studies that show: inbreeding may impact most strongly fitness components other than those commonly assessed; genetic drift and founder effects may make effects of inbreeding in any given population highly unpredictable; and inbreeding depression likely has multiple different genetic bases that respond to selection in divergent ways. Recent studies provide conflicting evidence regarding the interactions of inbreeding with environmental conditions. Impacts of inbreeding may be due to alleles with environmentally specific effects, or may be due to unconditionally deleterious alleles. Inbred organisms may or may not be more susceptible to stress. There is accumulating evidence that inbreeding depression has compromised the viability and persistence of natural populations. More work is needed to allow prediction and possible amelioration of inbreeding impacts in threatened populations.

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#### FISHING TOP PREDATORS LEADS TO OVERGRAZING AND DISEASE IN A KELP FOREST.

To understand the role of top predators in a marine reserve, I investigated recruitment, fished predators and disease of purple sea urchins (*Strongylocentrotus purpuratus*) at kelp-forest sites around the California Channel Islands. Urchin abundance was independent of recruitment, indicating post-recruitment factors were important in regulating populations. Urchins were less abundant where predators, particularly spiny lobsters, a fished species, were abundant. Kelp density declined with urchin abundance because urchins feed on kelp and can transform kelp forests to barrens. Disease outbreaks among urchins tended to occur at higher than average densities at a site and were followed by a reduction in density the following year. In a barrens situation, urchins may be starved and not be able to commit sufficient resources to battling bacterial infections. High urchin densities may also increase the transmission efficiency of diseases among individuals. At a marine reserve, lobster abundances were relatively high, presumably due to restrictions on fishing. Urchin abundance at the reserve was low, kelp was abundant and urchin disease was absent. The reserve appears to provide sufficient protection for top predators so that grazer density is low and kelp density is high. High kelp density in the reserve provides important habitat for several species.

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#### A COMPARISON OF ENDEMIC BIRD AND ENDEMIC MAMMAL AREAS OF AFRICA.

BirdLife International lists 226 mainland African bird species as restricted range species. These bird species are designated as such for having breeding ranges of less than 50,000 km<sup>2</sup>. Areas where two or more of these species overlap were mapped by BirdLife into 21 “Endemic Bird Areas” (EBAs). Here we present the first attempt to map the “Endemic Mammal Areas” of Africa by applying the same methods as employed for birds. We find 24 Endemic Mammal Areas. As with birds, more than 200 mammal species qualify as having a restricted range, however, many of the distribution patterns we show are unique to mammals. For example, the Cape Fynbos, Lesotho Highlands, South-east African Coast and Eastern Zimbabwe Mountains EBAs have no endemic mammals. In contrast, clear “Endemic Mammal Areas” with no endemic birds stand out at Lake Chad, the Jos Plateau, the South-west, Central, and North-east DRC, and Western and Eastern Sudan. From this it is clear that conservation priorities for one taxon will never reveal all of those for other taxa. Nevertheless, that 17 centers of endemism overlap between the two taxa suggests that assessing endemism for one taxon is likely to reveal useful areas for conservation attention more generally.

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#### FLORIDA PANTHER GENETIC RESTORATION: STRATEGIC MANAGEMENT OF AN INSULAR CARNIVORE POPULATION.

The Florida panther (*Puma concolor coryi*) population, currently estimated to number between 60-70 individuals and restricted to the southern Florida peninsula, is all that remains of a historically contiguous puma population in the southeastern United States. A strategic genetic restoration plan that involved the translocation of 8 female Texas puma (*P. c. stanleyana*) was implemented in 1995 in an attempt to reverse the extinction trend predicted by earlier population viability analyses. This translocation was intended mimic the former natural genetic exchange among the various puma subspecies and to correct physical abnormalities attributable to low genetic diversity. The goal of the plan was that the resultant puma population in Florida, after the assimilation of several generations of intercrosses, could trace 20% of its genome back to the Texas population. Preliminary analyses suggest that our introgression goal has been achieved and that a marked reduction in the maladaptive physical traits believed to be manifestations of inbreeding has occurred. Although the full extent of genetic restoration on the Florida panther population may only become evident over the next decade, we believe this management action has been a success and may serve as a template for managing other fragmented and isolated large carnivore populations.

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## POTENTIAL OF VISIBLE COLOR DIGITAL IMAGERY FOR AERIAL CENSUS OF HALEAKALA SILVERSWORDS.

High spatial resolution remote sensing offers largely untapped potential for censusing and monitoring rare plant populations. The Haleakala silversword is a federally listed threatened species whose natural range is restricted to the highest elevations on Maui. With its distinctive foliage set against the volcanic background, the species provides an excellent test of the capabilities of remote sensing to provide a spatially explicit, individual-based approach to monitoring. We used a helicopter-mounted, high spatial resolution color digital camera system to image ten permanent census plots. Ground-based surveys of known accuracy were compared to photo interpretation (counts) and automated computer classification. Several challenges in the automation of censusing became evident. Compared to photo interpretation, automated classification inaccurately estimated silversword size in aerial images. Both methods demonstrated higher accuracy in the largest size classes. Furthermore, many small individuals were missed in both counts and automated classification. Finally, both human counts and classification did not accurately differentiate between living and dead individuals. These problems could likely be overcome by using a longer lens and color infrared imagery. Remote sensing can provide a rapid partial population census, which may be adequate for monitoring plants that are rare, but are not in immediate danger of extinction.

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## ECONOMIC CONSIDERATIONS OF PRIVATELY OWNED PROTECTED AREAS.

Privately owned parks continue to proliferate worldwide. Their rapid expansion represents an important yet little understood private sector incursion into an activity long dominated by governments. This presentation examines economic issues surrounding establishment and operation of privately owned natural areas. I interviewed owners of sixty-eight private parks in Costa Rica to learn more about reserves' underlying economics. Key findings include: 1) private parks require an expanded definition of optimal reserve size – one in which quality of protection takes precedence over quantity of land protected; 2) profit was a powerful motivator behind private reserve operation, even though many owners did not rely on their reserves for revenue generation; and 3) an important non-market value of private parks was the high bequest value owners placed on them. Last, I identify key information gaps that resource economists can help fill regarding this increasingly popular conservation tool. The analysis contributes to our understanding of private reserves on both theoretical and empirical levels. It should be of interest wherever biodiversity remains threatened, wherever new conservation partners are being sought, and wherever private reserves are being established – which includes most of the industrialized and developing world.

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## ADJUSTING TO LIFE ON THE OUTSIDE: THE REINTRODUCED YELLOW-FOOTED ROCK-WALLABY STORY.

Following on from the recommendations of both the 1993 Reintroduction Biology Conference and the 1994 Rock-wallaby Symposium, captive-bred Yellow-footed Rock-wallabies (*Petrogale xanthopus xanthopus* and *P. x. celeris*) have been successfully reintroduced into areas of their former ranges in both South Australia (1996) and Queensland (1998). The aim of both reintroductions was to develop successful methods for reintroducing rock-wallabies, and to gain insight into how captive-bred animals adjust to their often harsh semi-arid environments through extensive pre- and post-release monitoring. The establishment of a database on various physiological and ecological parameters of captive animals has allowed the monitoring of individual animal adjustment to the wild upon their release. Although analysis is still in a formative stage, consistent trends are emerging whereby adjustment takes several months to occur. Adoption of a 'wild' diet by released wallabies occurred after two to three months. Similarly, home ranges slowly expanded post release until individual ranges were similar to those of wild-born animals. Highly significant decreases in most haematological and biochemical blood parameters occurred five months post release, but reverted to pre-release values six months later. Currently, growth and reproduction rates, water usage, metabolic rate and genetic hierarchy are also being examined for changes.

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## THERMAL LIMITS TO PARASITE DEVELOPMENT AND THE DISTRIBUTION OF AVIAN MALARIA IN HAWAII.

Hawaiian honeycreepers are among some of the most endangered birds of oceanic islands. Introduced mosquito-borne avian malaria, *Plasmodium relictum*, has been identified as a major limiting factor of low to mid elevation bird populations. Through field and laboratory experiments we determined that 13°C was the minimal threshold temperature for the development of *P. relictum* in the mosquito vector and assessed the current distribution of native bird species in light of this information. Isotherms for the Hawaiian Islands are based on a generalized lapse rate where 13°C corresponds to an elevation of 1800 meters. As predicted by this threshold temperature the highest densities of endemic forest birds are found on the high islands of Maui and Hawai'i. Conversely, the low islands of O'ahu and Moloka'i have experienced almost complete extinction of native birds. Kaua'i appeared to be an exception to this generalization. Field measurements from the Alakai Swamp, however, indicate that annual mean temperatures were 2-3°C cooler than expected making much of the Alakai habitat marginal for *Plasmodium* development and hence malarial transmission. Our data supports the hypothesis that avian malaria restricts Hawaiian honeycreeper populations and may be extrapolated to predict the relative risk of avian malaria to other oceanic avifauna.

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## DEMOGRAPHIC CHARACTERISTICS OF A RESTORED ELK POPULATION.

Restoration attempts of elk populations in the eastern North America have met with limited success. We studied demographics of 718 elk that were translocated to Kentucky from 5 western states. Mortality included capture myopathy (58%), automobile collisions (7.5%), poaching (2.5%) and meningeal worm (*Parelaphostrongylus tenuis*) (2.5%). Annual survival was highest among yearling females (0.95) and lowest among yearling males (0.89). Pooled seasonal survival ranged from 0.93 to 1.0. Calving rates for adult females during 1998, 1999, and 2000 were 61%, 53%, and 92%, respectively. The low calving rate observed in 1999 was due to Allee effects caused by the inability of many females to find mates. Reproduction by yearling females, consecutive year pregnancies, and twinning suggest Kentucky elk experience a high nutritional plane. The high survival and reproductive rates exhibited by elk in Kentucky are characteristic of colonizing ungulate populations in areas devoid of predators and competitors. Continued monitoring of the newly established elk herd in Kentucky will be necessary in order to determine if the observed demographic vigor is to be the expected norm or just another example of irruptive oscillation.

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## OPTIMIZATION MODELING FOR PIPING PLOVER RECOVERY IN THE NORTHERN GREAT PLAINS.

The Great Plains population of piping plovers (*Charadrius melodus*) is federally threatened and continues to decline. We developed an optimization model to determine if recovery of the population is economically and demographically feasible using predator exclusion to increase reproductive success on alkali wetland beaches. We included empirical estimates of reproductive success and the costs of materials, labor, and transportation. A combination of nest cages and permanent electric fencing around a beach was the most cost-efficient strategy. Application of permanent or temporary electric fencing alone was least cost-efficient. Mean annual costs (amortized over 50 years at a discount rate of 5%) were minimized at approximately \$115,000 when the mean number of fledglings per breeding pair was constrained to >1.14, which is the level necessary to stabilize the population. Reproductive success was maximized at 1.3 fledglings/pair under the constraint that management could be applied to only 80% of pairs. This would result in an annual population growth rate of approximately 3%. Recovery of the population is feasible if management intensity is increased to protect >60% of pairs. We also show the value of optimization modeling in deciding how to allocate limited conservation resources for populations of special concern.

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## A POLICY AND CONSUMER STRATEGY FOR STURGEON CONSERVATION.

The order Acipenseriformes consists of 25 extant species of sturgeon and two species of paddlefish. They are a unique and relict lineage, imperiled by a range of anthropogenic factors, including overfishing to support global caviar markets, loss of spawning habitat, and pollution. In recent years, the Caspian Sea, cradle of world caviar production, has seen marked declines in catch trends and biological indicators for its three major commercial sturgeon species, beluga (*Huso huso*), Russian (*Acipenser guldenstaedtii*), and stellate (*A. stellatus*) sturgeon. Although the depauperate status of these species is well known, illegal harvest continues with support of black market trading and the demands

of caviar consumers worldwide. This presentation will describe a strategic suite of policy and consumer initiatives designed to promote conservation of sturgeon of the Caspian Sea and North America. Recent efforts to identify more sustainable alternatives, including aquaculture products and limited wild alternatives, will be described. Our presentation will also examine national and international policy priorities to help promote the sustainability of fisheries for wild sturgeon in the Caspian Sea and North America.

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#### STRATEGIES FOR RHINO CONSERVATION.

Biological and operational factors affecting the success of rhino conservation were studied in 87 different populations in Africa and Asia. The involvement of local communities and budgets devoted to protection explained 55% of the variance of success. However, biological factors were largely unimportant in explaining successful conservation of rhinos.

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#### T.R.E.E. CENTER PROGRAMS: EDUCATION IN THE FORESTS OF HAWAII.

Few opportunities exist in Hawai'i for K-12 students to be immersed in environmental science based education in an outdoor setting. To meet this need, the Tropical Reforestation and Ecosystems Education Center (T.R.E.E. Center) developed

Camp Papaloa's Trees as Habitat, Nature Awareness, and Education Camp in July, 2000. This unique camp is a residential outdoor environmental education camp for students ages 9 to 14. This camp involves students in activities that are designed to integrate the sciences of forestry, biology, ecology, and ethnobotany with art and nature awareness. Students experienced hands-on techniques of habitat restoration through a koa tree (*Acacia koa*) planting project. Instructors included Hawai'i forestry biologists, endangered species biologists, entomologists, and astronomers. T.R.E.E. Center is a non-profit organization whose mission is to promote and conduct tropical reforestation and soil conservation in Hawai'i.

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#### EFFECTS OF LANDOWNER ATTITUDES AND BEHAVIORS ON BREEDING BIRDS IN A DYNAMIC LANDSCAPE.

Although the majority of land in the United States is privately owned, the effects of landowner attitudes and behaviors on breeding birds are largely unknown. To investigate how humans influence breeding birds, we carried out a survey of all private landowners (n = 1694) along three breeding bird survey routes in a rapidly urbanizing landscape. Our survey was designed to ascertain how much food and shelter landowners provided for birds, how vegetation was modified for birds, number of cats allowed outside, landowners' perceptions of birds, activities carried out on the land, specific types of landcover on the property and how landowners use it, and what landowners are likely to do with their land in the future. Of the 969 landowner responses (58.6% response rate), 65% fed birds, 46% had bird houses, 54% planted or maintained vegetation for birds, and 26% owned cats allowed outside, which commonly depredated house sparrows, blue jays, and American robins. The majority of landowners lived in developing rural (51%) and rural (28%) areas and approximately 32% expected to sell or develop their land in the next five years. These results indicate that private landowners directly and indirectly affect both the landscape and the breeding birds.

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#### AN EXPERIMENTAL TEST OF WHETHER HABITAT CORRIDORS INFLUENCE SEED DISPERSAL.

We tested whether seed dispersal by birds is facilitated by corridors that join adjacent patches of habitat. Habitat patches were 128 x 128m areas of second growth in a matrix of mature pine. Three patches made up each of four experimental units, within which a "source" patch was equidistant from two "receiver" patches, one joined by a 32m wide corridor to the source patch, the other not. During a two-year study, we placed native fruits in the source patches and seed traps in the receiver patches to monitor the movement of seeds by birds from the source to receiver patches. We predicted that more seeds would be dispersed to receiver patches connected by a corridor than to the unconnected (isolated) receiver patches. During the first year, this prediction was supported ( $p < 0.10$ ) in two of the experimental units for one species of bird-dispersed plant and in one of the experimental units for another species. During the

second year, very few seeds were dispersed and no corridor effects were apparent. We conclude that habitat corridors influence seed dispersal in some sites in some years.

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#### SYNERGESTIC EFFECTS OF INTRODUCED SPECIES ON NEW ENGLAND KELPBEDS.

Recently, numerous species have been introduced and are now established in the the Gulf of Maine. The presence of these invasive species may render paradigms describing subtidal communities in the Gulf of Maine obsolete. In 1983, the green alga *Codium fragile* was observed at the Isles of Shoals, Maine, and has since replaced the native kelp (*Laminaria* spp.) as the dominant seaweed. Experiments manipulating kelp and *Codium* densities revealed that *Codium* does not directly inhibit growth or survival of kelp, although the presence of native kelp does inhibit *Codium* recruitment. *Codium* will successfully recruit to gaps in the kelpbed and once established inhibits recruitment of kelp. A second non-indigenous species, *Membranipora membranacea* grows epiphytically on ca. 85% of kelp, and experiments reveal that the presence of *Membranipora* reduces growth and survival of kelp resulting in defoliation of kelp plants and gap formation in kelp bed. In the absence of *Codium*, kelp re-colonizes these gaps, but when present, *Codium* colonizes and prevents kelp re-colonization. Manipulations of herbivores demonstrate that herbivory will reinforce *Codium* dominance. Thus, the demise of New England kelpbeds results from the interactive effects of two non-indigenous species.

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#### CONSERVATION IMPLICATIONS OF PREY BASE AND LANDSCAPE DIVERSITY ON NORTHERN GOSHAWKS IN SOUTHEAST ALASKA.

The island biogeography of southeast Alaska creates a unique mosaic of species diversity and occurrence, resulting in a variable prey base for northern goshawks (*Accipiter gentilis*). Our primary objective was to determine the breeding season diet of goshawks nesting within two distinct bioregions in southeast Alaska. Secondly, we evaluated landscape features within goshawk home ranges to elucidate the relationship between prey species occurrence and goshawk diet. Analysis of prey deliveries, recorded with video surveillance systems, as well as prey remains and pellets indicated that these goshawks consumed small to medium sized birds and mammals. Birds were more prevalent (90.6% in south vs. 75.5% in north) in the diet of goshawks nesting in the southern bioregion where the red squirrel (*Tamiasciurus hudsonicus*) was absent. Within bioregion, considerable variation existed in the specific composition of the diet and was correlated with landscape features in the home range. For example, goshawks nesting near the beach preyed more on northwestern crows (*Corvus caurinus*). Recent guidelines imply enhancement of prey habitat will result in greater prey abundance, consequently benefiting goshawk populations. Our results suggest that the specific effects of land management practices on prey should be evaluated before implementation of these guidelines.

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#### CAPTIVE PROPAGATION AS A TOOL FOR THE RESTORATION OF ENDANGERED HAWAIIAN FOREST BIRDS.

The Hawai'i Endangered Bird Conservation Program (HEBCP) is a public-private partnership program dedicated to assisting the recovery of threatened endemic forest birds by providing a source of captive-reared birds for reintroduction into managed native habitats. In 1993, The Peregrine Fund was invited by the U.S. Fish and Wildlife Service and the State of Hawai'i's Division of Forestry and Wildlife to develop the HEBCP (now administered by the Zoological Society of San Diego) and to participate in the conservation and restoration of the native avifauna. The goal of the program is to develop the technology required to propagate and release native species (often species that are unique to aviculture) concomitant with private land-owner and governmental agency efforts to restore and manage native ecosystems. To date, the program has hatched over 250 chicks of 12 native forest passerine species at the Keauhou Bird Conservation Center (KBCC) and the Maui Bird Conservation Center (MBCC) to include species in the taxa Corvidae, Monarchidae, Drepanidinae, and Turdinae. Six species have been successfully bred in captivity (alala, amakihi, palila, puaiohi, Hawai'i creeper, Maui parrotbill) and five species have been reintroduced into native habitat.

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#### NOVEL FOREST FRAGMENTATION EFFECTS ON BIRD ASSEMBLAGES IN A NOVEL LANDSCAPE CONTEXT.

We report findings of a large-scale “natural experiment” in south-eastern Australia. The study measured landscape context and habitat fragmentation effects on birds and was conducted in a forest mosaic characterized by different landscape contexts:- large continuous areas of native forest, extensive stands of exotic Radiata Pine plantation, and forest patches scattered throughout the plantation. Eighty-five remnants were randomly selected across several stratifying variables - 4 size classes, 2 shape classes, 2 isolation classes, and 5 forest types. A further 80 sites were selected in continuous forest and in Radiata Pine stands. Strong gradients in bird assemblages were found, governed by landscape context, remnant size and shape effects; and in the case of Radiata Pine sites, the extent of surrounding native forest. These gradients could be explained by bird life histories such as foraging guild and nesting height. Eucalypt fragments of all sizes and shapes have significant conservation value as they contain many native taxa, some of which are more abundant in fragments than in continuous native forest. Eucalypt remnants should not be cleared during plantation establishment – as has often occurred during past.

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#### THE EFFECTS OF CATTLE ON POND-DWELLING TURTLES IN THE WESTERN PIEDMONT OF NORTH CAROLINA.

Few studies have addressed intraspecific variation in life-history characteristics among habitats of varying quality. We used an extensive mark-recapture study to compare semi-aquatic turtle populations among twelve farm ponds with varying cattle impact in the vicinity of Davidson, NC. We compared turtles at the community level while testing for differences in morphology and reproduction among the ponds. Two species, the eastern mud turtle (*Kinosternon subrubrum*) and the painted turtle (*Chrysemys picta*) were found in most ponds. We discovered considerable variation in species composition and relative abundances among the ponds. We also found that *K. subrubrum* size is inversely correlated with concentrations of nitrite/nitrate and ammonia and that *K. subrubrum* egg size is inversely correlated with concentrations of nitrite/nitrate and overall cattle impact. *Chrysemys picta* morphology and egg size was not correlated with measured characteristics of water quality or with cattle impact. Our results indicate that while providing critical habitat for freshwater turtles, heavy use of farm ponds by cattle may be detrimental to some species of turtles.

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#### CONSERVATION IMPLICATIONS OF GENETIC PHYLOGEOGRAPHY OF AMPHIDROMOUS GOBIOIDS.

The amphidromous life history tactic employed by many inhabitants of lotic tropical environments has resulted in circumtropical distributions. If populations of these organisms are to be managed properly it may be imperative that biogeographical dynamics and taxon specific nuances be identified and taken into account before formulating conservation strategies. This study sought to test whether the amphidromous condition in several gobioid genera might constrain population dynamics and biogeography so as to allow a blanket conservation strategy. Three mitochondrial DNA loci (ATPase, Cyt b, D-Loop) were sequenced from specimens from 9 genera from 8 locations in the Caribbean to the Western Pacific, including four transisthmian geminate pairs. Genetic data were analyzed for patterns and possible calibration of taxon specific molecular clocks. Phylogeographic analysis was also performed and examined for general trends. Both transisthmian and the greater geographic range data show a diversity of patterns and point to the lack of a general rule that could be employed in the formulation of a blanket conservation strategy for amphidromous gobioids. It is concluded that differences within even closely related species employing the same life history strategy should be taken into account, to at least the generic level, when formulating conservation strategies.

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#### CONCLUSION: CAN WE SUSTAIN HAWAIIAN ECOSYSTEMS?

Some incorrectly regard Hawai'i as one of conservation biology's basket cases because of the dramatic losses already suffered and the abundant factors in force to erode what is left. We contend that U.S. mainland ecosystems, given unabated action of similar forces responsible for continuing degradation – habitat destruction, habitat fragmentation,

biological invasion, and cascading effects toward biodiversity loss, will be showing comparable symptoms by the end of this century. The heart of the issue, whether for Hawai'i, for the U.S. mainland or anywhere else, is: Can science-based management for conservation have any real and lasting influence on increasingly ubiquitous habitat disruption and mixing of species by humans? Hawai'i is especially a testing ground for ecological study, prevention, and management of biological invasions. But to stem the seemingly inexorable forces of degradation clearly requires a change in fundamental beliefs driving modern culture (including scientific culture) as well as technological tools to reduce new invasion and repair damage already done. Hawai'i retains rich, still-savable, endemic biodiversity and provides an invaluable "back-to-the-future"-style microcosm where conservation biologists with a positive attitude can develop, refine, and test the long-term effectiveness of the tools of their trade, including techniques for altering human behavior.

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#### PATTERNS OF MAMMAL AND BIRD ENDEMISM IN MALESIA: IMPLICATIONS FOR CONSERVATION.

The diverse habitats and evolutionary history of Malesia have combined to produce extraordinary levels of endemism in flora and fauna. Using an ecoregion framework we analyzed endemism patterns of birds and mammals for the 61 ecoregions in Malesia. With the exception of the Solomon Islands, both bird and mammal endemism peaked in Wallacea, a region of transition between Australian and Oriental fauna. Bird and mammal endemism were correlated throughout Malesia. Bird and mammal endemism was greater in lowland ecoregions relative to montane ecoregions. However, when analyzed as a percent of the fauna, montane ecoregions prevailed. Rodents and bats comprised more than two-thirds of the endemic mammals in this region. The natural habitat of many lowland ecoregions has been reduced to isolated patches of forests in a few protected areas. Most of the montane ecoregions that have high numbers of endemic birds and mammals have also lost more than 50% of their habitat. Rapid destruction of forests, especially in Indonesia, threatens the survival of many lowland endemics, while isolating montane endemics. We recommend several immediate conservation actions to conserve many of these endemic species from extinction.

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#### FIGHTING FIRE WITH FIRE: AN INVASION BY A BIOLOGICAL CONTROL OF WEEDS AGENT.

The invasive species problem has stimulated renewed interest in biological control in natural areas. This form of ecological engineering involves the importation of exotic natural enemies to limit populations of invasive species. The possibility of persistent, sustained limitation of an invasive species by a co-evolved natural enemy is a seductive idea, based upon a simplistic ecological model. The evidence, however, suggests that most biocontrol falls short of population limitation, and that ecological risks can be higher than predicted. I will discuss the population interactions associated with host range expansion by *Rhinocyllus conicus*, a floral-feeding weevil introduced worldwide to control Eurasian thistles, in the context of our longterm data on interactions of native thistles and their adapted floral insects in sand prairies. We have found both significant direct effects of this weevil on native thistles and indirect effects on native insects. This case history illustrates the ecological risks of biocontrol when the targeted invasive has native relatives and when biocontrol agents are not species-specific. It also provides clues to predicting the invasiveness of exotic insects. I conclude that to assess environmental costs realistically, ecological data on population parameters are required to supplement the behavioral and developmental data from host specificity tests.

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#### MACROINVERTEBRATE COMMUNITY COMPOSITION OF *ARUNDO DONAX* IN A SOUTHERN CALIFORNIA RIPARIAN HABITAT.

The giant reed, *Arundo donax*, is an exotic invasive plant that has become widely established throughout southern California's riparian ecosystems. It is widely known to have many negative affects on riparian systems, however surprisingly little is known about invertebrates associated with this plant. In this study, macroinvertebrate composition from root balls of the giant reed, *Arundo donax*, were analyzed from the Santa Margarita River at Marine Corps Base Camp Pendleton, San Diego County, California. Removal of *Arundo donax* for analysis was done by means of heavy equipment. A total of 2,581 invertebrates were captured in this study, representing over 140 species. At least sixteen arthropod orders have been identified. Exotic species were more abundant than natives in the samples collected, and three exotic species made up 41% of the total number of captured arthropods. No sensitive species were found in association with *Arundo donax*, indicating that the use of heavy machinery may be a suitable method for its removal.

This study provides important information related to the macroinvertebrates associated with a prolific exotic plant found throughout many of southern California's riparian areas, and highlights that it is poor habitat for native species adding support for the existing removal programs.

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#### WILDLIFE FORENSIC APPLICATIONS OF DNA TYPING: EMPIRICAL EVALUATIONS AND GUIDELINES.

Illegal harvesting and trade is one of the greatest threats to many plant and animal species. DNA-typing can help detect poaching by identifying the species, the individual and even the geographic population/region of origin of wildlife products or body parts. We used computer simulations and real data to assess the power of microsatellite DNA markers for (i) matching two tissue samples from an individual and (ii) assigning individuals (or body parts) to a population of origin using assignment tests. Standard formulas for estimating the power of markers for matching two tissues (from the same individual) were biased low by 1-3 orders of magnitude in some populations of endangered bears, wolves and wombats. Thus more markers will often be needed than is suggested by standard formulas. When assigning an individual (or wildlife product) to its population of origin, a fully-Bayesian method (StrucAssign software) is more powerful than the Monte Carlo simulation-based method (GeneClass software). However, unlike GeneClass, StrucAssign assumes that the true population of origin has been sampled. Thus, both methods should be used when the true population of origin might not have been sampled. DNA typing and recent statistical methods promise to help detect and reduce illegal exploitation of wildlife.

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#### USING SURVEY DATA TO PLAN WILDLIFE HABITAT CORRIDORS IN SOUTHERN CALIFORNIA.

Protecting wildlife corridors among habitat islands in urban landscapes is essential for species conservation, but often information needed to design functional corridors is lacking. Inventories of biodiversity are needed to evaluate the responses of wildlife populations to connectivity at a regional scale. We intensively surveyed vertebrates within fragmented habitat connecting the Santa Ana and the Palomar mountains in the South Coast ecoregion of California. Over a two year period, we assessed the distribution and relative abundance of mammals, birds, reptiles, amphibians, and fish using a variety of field techniques including tracking stations, remote photography, anabats, point counts, pitfall traps, road driving transects, and seining. We detected over 196 vertebrate species within the regional study area, including over 32 species of herpetofauna, 117 species of birds, 14 species of small mammals (non-volant), 10 species of bats, 12 species of large mammals, and 11 species of fish. The broad diversity of habitats used by wildlife highlights the importance of designing corridors at multiple spatial scales across a range of focal taxa. These results are providing the basis for a corridor protection plan currently being developed by an interdisciplinary planning group comprised of state and federal agencies, non-governmental organizations, researchers, and other stakeholders.

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#### EFFECTS OF URBANIZATION ON AQUATIC INVERTEBRATE COMMUNITIES IN HAWAII.

As part of the U.S. Geological Survey's National Water Quality Assessment (NAWQA) program, nine streams on the island of O'ahu were surveyed in the summer of 1999 to evaluate the effects of urbanization on stream biota. Invertebrate communities were examined in relation to environmental variables at various spatial scales, including watershed characteristics, land use, instream habitat, and water quality. Of the taxa identified to species, 13% were native and 87% were introduced. The most abundant taxa in the samples, chironomids, hydroptilids and hydropsychids, were all introduced to Hawai'i. Total invertebrate abundance was highest at forested sites, while taxa richness was greatest at urban sites. At urban sites, channelization and reduced canopy cover were associated with higher mean temperatures and increased daily temperature fluctuations. At urban sites, <50% of the invertebrates collected were insects, while in forested sites >85% were insects. Insect abundance was correlated with canopy cover, embeddedness, and velocity. Ninety-nine percent of the insects collected in riffle habitat were tricopterans and dipterans, and the ratio of tricopterans to dipterans decreased with urbanization. As Hawai'i's population increases,

urbanization will continue to encroach on stream systems. Understanding the relation between aquatic invertebrate communities and urbanization is needed for sound management decisions.

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#### GENETIC AND DEMOGRAPHIC MANAGEMENT FOR THE ENDANGERED SAN CLEMENTE LOGGERHEAD SHRIKE RECOVERY PROGRAM.

The San Clemente loggerhead shrike (*Lanius ludovicianus mearnsi*), endemic to the southern-most of California's Channel Islands, was federally listed as Endangered in 1977. By the mid -1980's as few as five breeding pairs remained. Beginning in 1990, efforts to develop a captive flock of shrikes began in order to provide a reservoir of genetic material, a hedge against stochastic events, and a source of animals to fuel a release program. Captive propagation of shrikes has proven successful and release efforts are now underway. Genetic and demographic management of the program has proven complex, as introgression between the captive and wild population is frequent. While the captive population is managed intensely for genetics and demography, the wild population is monitored closely and manipulated opportunistically. Priorities for management are maintenance of genetic diversity in the captive flock as well as providing a number of genetically diverse individuals for release great enough to overcome the demographic challenges facing the wild population.

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#### DAYS OF FUTURE PAST: APPLYING PALEOECOLOGY TO CONSERVATION IN THE BOREAL FOREST AND BEYOND.

The management of terrestrial and aquatic ecosystems for habitat and species conservation must take into account both present conditions, and the centennial to millennial scale history of the systems. Fortunately, paleoecological techniques for reconstructing past terrestrial and aquatic environments have become increasingly sophisticated and widely applied. This allows for the analysis of long term dynamics and disturbance regimes at high temporal resolution over broad areas. The results presented here illustrate the application of tree-ring analysis, fossil pollen analysis, fossil diatom analysis and geochemical analysis to resolve the long term dynamics and disturbance regimes in Wood Buffalo National Park, Canada and adjacent boreal forest. Three salient observations arise from the history of these terrestrial and aquatic systems: 1. the present ecosystems are often in transitory states due to long term processes of climatic change, 2. current conditions of the systems are strongly influenced by ancient disturbance events, and 3. some natural disturbances have a propensity to occur synchronously at separate locations over large geographic areas and impact both local systems and metapopulation dynamics. It can also be shown that these three features are common to both to the boreal forest, and to many other systems in temperate and tropical regions.

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#### INVASION CORRIDORS TO THE GREAT LAKES: ROUTES AND MECHANISMS.

The Great Lakes have been invaded by at least 160 species, mainly via the release of ballast water. Genetic and biogeographic studies have revealed that eastern European species arrived to the Great Lakes following invasions of habitats in northern Europe. Ships that illegally discharge freshwater ballast pose the greatest invasion risk to the Great Lakes, followed by those that declare 'no ballast on board' status; ships that exchange ballast on the open ocean appear to pose a low risk. Lake Superior receives a disproportionate amount of both saline and freshwater ballast water, yet has been the initial site of colonization of relatively few invaders. This pattern may be due to the relatively low number of surveys conducted on the lake, to low habitat heterogeneity, to physiological intolerance of invaders to ambient conditions, or to the absence of facilitative interactions by other species.

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#### PATTERNS OF DISPERSAL IN THE FLORIDA PANTHER: EFFECTS OF FRAGMENTATION AND POPULATION AUGMENTATION.

We studied dispersal in 28 radio-collared Florida panthers (*Puma concolor coryi*) in southern Florida from 1986 to 2000. Male panthers dispersed farther (mean = 68.4 km) than females (mean = 20.3 km) but were less successful in establishing home ranges. Independence and the initiation of dispersal occurred at about 14 months of age and lasted for an average of 7 to 9.6 months for females and males, respectively. A recent increase in long distance male dispersal events may be related to an increase in reproduction and subsequent high population density resulting from the introduction of female cougars (*P. c. stanleyana*) into south Florida. Since 1998 at least 3 male panthers have crossed a fragmented landscape that was formerly thought to be a barrier to dispersal. However, the pattern of dispersal in this population remains circular and frustrated. Although the population exhibits the behavioral ability to colonize nearby vacant range, successful dispersal to these areas could be facilitated by habitat restoration and translocation. Coordinating panther recovery with other statewide and regional initiatives such as the Florida Greenways Project could elevate this endangered subspecies to an effective conservation flagship.

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#### PUBLIC PARTICIPATION IN WATERSHED RESTORATION: STAKEHOLDERS, AUTHORITIES AND PROCEDURAL JUSTICE.

Public support is an essential ingredient for successful restoration of damaged ecosystems through environmental regulation. One way to secure that support is by engaging the public in rule-making processes that satisfy the requirements of procedural justice (e.g., perceived fairness of authorities). We analyzed a public involvement process used by the North Carolina Division of Water Quality to draft rules for reducing nutrients in the Tar-Pamlico watershed to see if procedural justice requirements were met and were correlated with satisfaction with the resulting regulations. A rushed timeframe compromised several elements of procedural justice, including appropriate representation and ability to digest technical information. Most participants agreed that the process was fair, that they had ample opportunity to speak, and that the facilitators were unbiased. Satisfaction with the rule-making process as a whole was mixed, and satisfaction with the outcome limited. The behavior of regulatory authorities is an important contributor to perceptions of fairness. As is often the case, the Division of Water Quality played a multitude of conflicting roles ranging from technical expert to neutral convenor. Although agency personnel were well-regarded by participants, their dominant role led some to question the openness of the process.

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#### THE FLORIDA MASTER NATURALIST PROGRAM – A NEW MODEL FOR ENVIRONMENTAL EDUCATION OUTREACH.

The Florida Master Naturalist Program (FMNP) is a University of Florida environmental education program for adults. Objectives are to create a more environmentally aware citizenry and to prepare persons to assist in environmental education programs as interpretive naturalists. FMNP students include interested persons, ecotour operators, teachers obtaining CEUs, etc. Three 40-hr. modules are being developed: Freshwater Wetlands, Coastal Systems, and Upland Systems. Each module includes classroom, field, and practical interpretive experience and includes ecological, cultural, and interpretive training. Emphasis is placed on understanding ecosystem processes, the role of humans in shaping Florida's landscape, and conservation issues affecting the future of Florida's environment. The FMNP adopts a "train the trainer" approach. FMNP Instructors receive training in administering the program and are provided videos, slide presentations, and course workbooks. Instructors contribute their own personal experiences and expertise, particularly during field trips and practical experience, which constitutes 50% of the course. Instructors include representatives from natural resource agencies, nature centers, and county extension agents with expertise in natural resource issues. Incentives are incorporated in the FMNP both for Instructors to implement the program and for students to provide volunteer service, although volunteer service is not a requirement.

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#### PROPAGATION OF AN ENDEMIC, ENDANGERED MEXICAN CACTUS BY SOMATIC EMBRYOGENESIS.

Plant regeneration via somatic embryogenesis was achieved for *Obregonia denegrii* Fric.; an endangered cactus species endemic to Northeast Mexico. Embryos were developed from excised epicotils of 2 months old plantlets as well as callus portions, cultured in vitro with 0.5 mg l<sup>-1</sup> Benzil-Aminopurine combined with 0.1 mg l<sup>-1</sup> Naphtalene-

Acetic Acid; or with 5.0 mg l<sup>-1</sup> 2,4-D alone. Callus and epicotyl culture with some other growth regulators like Kinetin, combined with Indole-Acetic Acid, resulted in both, somatic embryogenesis and adventitious shoot proliferation. Growth and acclimatization of in vitro derived plantlets were evaluated, indicating that plants have sufficient vigor to support transplant for re-introduction programs.

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#### NATURAL RAINFOREST RESTORATION: SEED DISPERSAL AND RECRUITMENT IN REGENERATING HABITAT.

Vertebrate seed dispersers are assumed to be responsible for the distribution of many plant species, but little work has been done to document the dynamics of this process. I studied seed dispersal around Australian rainforest and found that rainforest frugivores spent substantial amounts of time in open forests where rainforest was regenerating. They spent time in and dispersed rainforest seeds to this habitat because they were attracted to the single fleshy-fruited species present, *Endiandra sieberi* (Lauraceae). Seed traps under fruiting *Endiandra* captured 10-55 times more rainforest seeds than controls and seedlings were 5-25 times more abundant under *Endiandra* than in adjacent regenerating forest habitat. Further, 89 % of visits of radio-tagged to regenerating habitat occurred during *E. sieberi*'s fruiting season and over 90 % of rainforest seeds were deposited during this time. This dispersal in activity meant that all dispersed seeds were of 8 rainforest species that fruited synchronously with *Endiandra* and these same species comprised >65 % of seedlings surveyed. This suggests that frugivores are not only moving substantial numbers of seeds into regenerating forest habitat, but that they are selectively seeding the area with a limited set of species that will most likely dominate the forest that develops.

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#### IDENTIFYING FOCAL SPECIES AT BIOREGIONAL SCALES THROUGH A MULTI-SPECIES MONITORING APPROACH.

Monitoring is required of land management agencies to assess the success of management activities in meeting legal, regulatory, and policy objectives. To this end, managers often look for shortcuts to monitoring ecosystem conditions and populations of species of concern. Several categories of species have been proposed to serve as representatives of other species or ecosystem conditions ("focal" species), including umbrella, keystone, indicator, and link species. We explored a process by which candidate focal species could be identified and evaluated for the Sierra Nevada based on empirical data. We identified candidate focal vertebrates based on several life history characteristics and then assessed the potential of a multi-species monitoring effort to provide population data on candidate species. Multi-species monitoring protocols were selected and their efficiency in detecting population change for all vertebrates was evaluated based on estimates of species' detectability and frequency of occurrence, specified levels of precision, and monitoring at a systematic grid extending across the Sierra Nevada. We concluded that numerous candidate focal species and over 50% of the 468 species could be adequately sampled. Data on candidate focal species' environmental relationships and associations with non-focal species should provide a sound basis for evaluating and selecting focal species for monitoring.

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#### NOTHING HAS YET LASTED FOREVER: CURRENT AND FUTURE LEVELS OF BIOLOGICAL AND CULTURAL DIVERSITY.

There is some literature describing spatial relationships between various environmental variables and biodiversity. From the anthropological literature, we know that cultural diversity can also be linked to environmental variables; one such is length of the rainy season. Pooling this information, we might expect some locations of high biological diversity to coincide with those of high cultural diversity. I test this idea, using digitized breeding ranges of passeriform birds, ranges of indigenous cultures of the western hemisphere, and length of the rainy season. I find significant overlap between cultural and biological diversity. This overlap will not remain at current levels: cultural diversity is eroding more rapidly than is biological diversity, meaning that future spatial patterns will be quite different. Using predictions of rates of culture loss, and of species loss, I go on to predict future concordance in levels

of biological and cultural diversity, show locations of highest concordance, and discuss implications for conservation of biodiversity.

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#### OLD-GROWTH FOREST RESERVES IN MINNESOTA: LESSONS FROM IMPLEMENTING A STATE-LEVEL BIODIVERSITY POLICY.

Old-growth forests covered over 50% of Minnesota's forested land in 1800, but today less than 4% of Minnesota's forests are considered old growth. Concern over the loss of Minnesota's old growth emerged in the 1980's. In 1988-1990, the Minnesota Department of Natural Resources (MNDNR) developed a general policy that defined old-growth, and designed a method to evaluate old-growth quality. In 1994, MNDNR and a group of stakeholders agreed to a target of protecting 27,000 acres of old growth on state-managed lands. The protection effort was stymied by conflict and lack of resources until 1998, when the agency renewed its commitment to the policy. Since 1998, interdisciplinary teams of managers selected over 23,000 acres of old growth for protected status, and the selection process will be completed in 2002. Numerous lessons emerged from implementing the policy. Keys to success were: 1) Clear quantitative targets, 2) face-to-face communication supplementing written policy, 3) commitment from internal & external stakeholders, 4) a standardized and science-based old-growth evaluation method, 5) a database of relevant information accessible to all disciplines involved, and 6) sufficient staff time dedicated to the process. Conflict and challenges remain, but we have demonstrated significant progress in a politically-charged environment.

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#### MITIGATING THE NEGATIVE EFFECTS OF DAMS ON MIGRATORY TROPICAL ISLAND STREAM BIOTA.

Tropical island stream ecosystems are typically dominated by diadromous macroconsumers (i.e. snails, shrimps, and fishes). Over their life cycles, these fauna migrate between stream headwaters and estuaries. On many tropical islands, increasing human populations and demand for freshwater have resulted in the construction of dams and water withdrawal structures that negatively affect the migration of these biota. In order to protect the biotic integrity and unique structure of tropical island streams, while simultaneously providing water for growing human populations, we need to develop better ways of designing and operating water withdrawal structures. We present research results from Puerto Rico on migration patterns of freshwater shrimps, an ecologically important group, and the effects of a typical low-head dam and associated water abstraction on shrimp migration. We provide recommendations for the operation of existing low-head dams, and compare effects of a low-head dam with a new pump-withdrawal system that does not involve dam or reservoir construction. Incorporating knowledge of the basic ecology of tropical island stream organisms into the design and operation of water withdrawal structures can mitigate many negative effects on migratory biota. Lessons from our work in Puerto Rico are applicable to tropical island streams worldwide.

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#### CONSERVATION STRATEGIES FOR A SOUTHERN CALIFORNIA RARE NARROW-ENDEMIC: *DUDLEYA MULTICAULIS*.

We investigated the population biology of *D. multicaulis* (Crassulaceae) in order to develop a conservation strategy based on both population genetics and specific life history parameters. The genus *Dudleya* is characterized by a number of geographically restricted species known only from a few localities, many of which are considered rare, threatened, or endangered. The results of the population genetic analysis indicate that there is low genetic variation within each population, low gene flow between populations, and significant genetic differentiation among populations. In order to identify the mechanism(s) for the pattern of variation observed we investigated the pollination biology, seed dispersal, and germination success of *D. multicaulis* from 5 isolated populations. The pattern of genetic variation correlates with the behavior observed of the primary pollinators, two species of small burrowing bees (*Andrena* spp., Family Andrenidae). Seed dispersal is gravity dependent and most seeds travel less than 100 cm. Germination under greenhouse condition was relatively high suggesting that other factors such as interspecific competition may affect recruitment. Based on these studies, guidelines for the conservation of *D. multicaulis* and other species with similar natural history characteristics are discussed.

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#### PREDICTING FISH INVASIONS IN THE ISLAND OF CALIFORNIA: A MULTIVARIATE AND GEOGRAPHIC APPROACH.

The decline of native fish populations and the invasion of non-native fishes are the most noticeable trends in California's freshwater fish assemblages over the last century. Based on our observations of California's freshwater fish fauna, we believe that changes in the composition of fish assemblages and the alteration of aquatic habitats are strongly linked. By combining watershed specific data on historic and present fish assemblages with geographic data on land use and development patterns, we investigated the question of whether watershed characteristics (natural and anthropogenic) are related to changes in the freshwater fish assemblages in California, using multiple regression and community ordination techniques. Our results indicate the following: 1. introduced species are positively associated with watershed characteristics indicating anthropogenic change (number of dams, density of aqueducts and ditches and proportion of watershed area developed) 2. species extinctions are positively associated with aqueduct density and the proportion of watershed area in agriculture, also indicating anthropogenic change 3. native species are positively associated with natural environmental characteristics (mean rainfall, stream density and mean elevation). The results suggest there are strongly negative effects on aquatic biological diversity from the landscape level changes we are making to the freshwater systems of California.

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#### ISLANDS OF PEOPLE: PREVENTING FRAGMENTATION IN PROTECTED AREAS.

Human settlements are found in almost all of the world's protected areas – even if protection status disallows populations living inside the area's borders. Some conservation planners advocate that local people should be expelled from protected areas. Others argue that the most effective strategy to ensure long-term protection is to find ways in which communities can live sustainably within a protected area. The purpose of this presentation is to compare two strategies that have been used by conservation managers to ensure the conservation of protected areas in which human settlements are found: 1) *voluntary community relocation* in which communities are moved from within a protected area to an area of lower conservation priority; and 2) *signing of agreements of intention* in which community members are granted permission to remain where they are, but agree to restrictions regarding their resource use. Research for this study was conducted in the Sierra del Lacandon of the Maya Biosphere Reserve in northern Guatemala – an area of social, cultural, and political complexity. Analysis suggests that the agreements of intention neither satisfy community needs nor address conservation requirements, and that under certain conditions, voluntary community relocations may be the best option for both communities and conservationists.

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DOING CONSERVATION BETTER: OPERATIONS RESEARCH TO LEARN ABOUT WHAT WORKS, WHAT DOESN'T, AND WHY.

Conservation practitioners work under highly dynamic conditions and require access to relevant and timely information to make the best decisions. They need to know which conservation strategies work, which do not, and why – and they usually cannot wait long for answers. *Operations research* – research designed to determine the efficacy of a particular strategy or tool – is one way to get to answers relatively efficiently. This paper presents results from the Biodiversity Support Program's (BSP) experience applying an operations research approach to learning about critical issues in conservation. Based on extensive consultation with conservation project managers, BSP selected six conservation strategies to investigate between 1996 and 2000. The research topics included adaptive management, creation of NGO-based alliances, decentralization, health incentives, sustainable agriculture, and ecoregion-based priority-setting. The research designs for these six topics varied from highly structured, quantitative studies to open, flexible "fishing expeditions". The results of BSP's research provide specific principles about how to achieve conservation using each strategy. Analysis across the topics reveals the conditions under which different research designs should be employed to learn about conservation strategies. Design selection must be based on the question being asked, the type of information needed, and the extent of previous research.

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## DO INBREEDING AND ENVIRONMENTAL FACTORS HAVE SYNERGISTIC EFFECTS ON HATCHABILITY IN A WILD POPULATION OF SONG SPARROWS?

Controversy exists about whether inbreeding and environmental factors have independent or multiplicative effects on fitness. This debate is fueled by recent studies suggesting that inbreeding depression is more pronounced in stressful captive environments or when intraspecific competition is greater and by other studies showing equivalent inbreeding depression in field and laboratory environments. If periods of adverse environmental conditions accentuate the deleterious effects of inbreeding, then conservation managers that only allow for the independent effects of inbreeding depression and environmental stochasticity are too optimistic. Prior research on a wild population of song sparrows on Mandarte Island, British Columbia suggested that inbreeding reduced hatching success of inbred females. Interestingly, ample evidence of constraints on hatchability and incubation behavior exists from studies of birds, and hatchability seems to be a trait that is affected by inbreeding in a variety of species. Here, we use nest records, data on unhatched eggs, and measurements of nest attentiveness to describe the effect of weather on egg hatchability and the evidence for synergism between inbreeding and environmental conditions. Our analysis involves 20 years of data on nearly 400 females for which inbreeding coefficients are known, all breeding attempts have been recorded, and all offspring have been color-banded.

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## EVALUATION OF HABITAT MANAGEMENT AND POPULATION AUGMENTATION TECHNIQUES FOR CONSERVATION OF AN ENDANGERED BUTTERFLY AND ITS THREATENED HOST PLANT.

Upland prairie habitats in Oregon's Willamette Valley are declining and highly fragmented due to agricultural and urban development and competition with nonnative species. Two federally listed species, Fender's blue butterfly and its larval host plant, Kincaid's lupine are associated with these upland prairie ecosystems. In an effort to conserve these taxa, the BLM is proposing to encourage butterfly colonization of a Kincaid's lupine population currently lacking butterflies by augmenting the site with additional lupine transplants, introducing nectar plants utilized by adult butterflies, and improving habitat through brush removal. To determine the feasibility and efficacy of these approaches, the BLM investigated impacts of brush removal on lupine and butterfly numbers, and evaluated cultivation and transplant potential of Kincaid's lupine and nectar plants at nearby sites. First year results indicated 75-95% establishment rates for lupine transplants and 50-75% for nectar species. The number of butterfly eggs increased seven fold following clearing of blackberry plants. Results suggest that these approaches may be useful in restoring the uncolonized lupine population and re-uniting the plant with its associated butterfly.

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## AFRICAN AMERICAN PERSPECTIVES ON CONSERVATION.

Environmental attitudes expressed by African Americans have been the topic of numerous studies in recent years. Many of these studies are based upon the assumption that African Americans show little concern for environmental issues. There have only been a few challenges to this notion. Results of this study show that African Americans do actually show concern for environmental issues. The survey information collected suggests that if these issues are separated into categorical groupings, there are some issues for which African Americans show great concern and others issues for which members of the population exhibit indifference or minimal concern. This study separates environmental issues into two very basic categories: 1) conservation and global issues, and 2) environmental health quality and local issues. Survey data indicates that African Americans, in fact, show some interest in former category but show a great deal of concern for issues related to the latter. Issues that may possibly have a discernable effect on the immediate local community are more prone to be addressed by African Americans than issues that are conservation oriented and have a more global impact.

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## STATISTICAL POWER OF MANTEL TESTS.

When defining units of conservation, researchers often begin by using a Mantel test to look for evidence of isolation by distance. The test examines the correlation between the genetic and geographic distances between populations or sampling locations, thereby providing insight into dispersal rates and distances. When conducting a Mantel test, a researcher must make numerous decisions, including determining the number of samples they need to collect, how to stratify those samples, and how to measure genetic distance. I use data from a computer model to examine the impact that these decisions have on statistical power. In a traditional Mantel test, several hundred samples are necessary to

achieve statistical power of 0.8 or higher for most parameter combinations. Power is enhanced when samples are divided more finely among many sampling locations. The performance of different measures of genetic distance depends on the nature of the genetic data. My results can provide guidance to researchers in designing and interpreting the results of Mantel tests.

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#### AFTER EXTINCTION: JUMP-STARTING AVIAN EVOLUTION ON OCEANIC ISLANDS.

In the last 3000 years and prior to historic discovery, anthropogenic impacts in the remote Pacific eliminated over half the native avifauna. The biggest losers were flightless rails, some 2000 taxa according to Steadman. Their volant ancestors colonized many hundreds of islands in the remote Pacific, establishing populations that evolved into the flightless species now known only as fossils. Barely a dozen species survive, such as the flightless rails (*Gallirallus*) of Guam, Lord Howe, New Zealand and Okinawa. With massive reduction in continental habitats for rails it is highly unlikely that the process of long distance recolonization and evolution of flightlessness can occur in rallids at present. In fact a much simpler solution is at hand. Using surviving populations of flightless rails raised in captivity it should be possible to jump-start rallid evolution. Although some Pacific Islands are marginal at best for flightless rails, many others still support natural vegetation and are free of Polynesian rats, brown tree snakes (*Boiga*) and other rallid predators. Guam rails are being raised for reintroductions. With the endorsement of indigenous inhabitants and their governments, flightless rails can be restored on many suitable Pacific Islands. Massive prehistoric extinctions of birds, giant tortoises, land iguanas, and other terrestrial vertebrates on oceanic islands need not be irremediable or forever.

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#### A MODEL FOR THE SIMULATION OF METAPOPOPULATION DYNAMICS OF SEA-DISPERSED PLANTS.

Metapopulation dynamics is highly relevant for the persistence of the populations of some plant species. In oceanic archipelagos these processes depend mainly on the dispersal of the propagules of the plants by the ocean. The study of metapopulation dynamics in nature is difficult to achieve. Here we propose a model to simulate the metapopulation dynamics of oceanic-dispersed plants. The model can be applied to different plant species, regions, and spatial scales. A series of factors determines the success in the exchange processes involved in metapopulation dynamics. Plant propagules should be able to travel to a given location, and, once there, to survive, grow and reproduce. Therefore we propose a spatially explicit stochastic model to integrate parameters related with the dispersal and regeneration capabilities of the species of interest together with spatially explicit factors, such as the geographical distribution of suitable habitats and the oceanic currents. The scale of the model is given by the input data sets describing the spatial characteristics of the region of interest. The simulations based on this model show the more probable dispersal routes for a particular species.

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#### STATUS OF INVASIVE NON-NATIVE PLANTS IN THE NORTHWESTERN HAWAIIAN ISLANDS.

The Northwestern Hawaiian Islands (NWHI) are remote islands and atolls that make up the geologically older, northwestern extent of the Hawaiian archipelago. Atoll vegetation is typically made up of indigenous littoral species and is fairly resilient to disturbances. However, the history of human occupation has greatly altered several of these remote sand islands. To quantify the current status of the vegetation, botanical surveys were conducted in 1999 on Midway Atoll and several other islands including Tern, Laysan, and Lisianski Islands and Pearl and Hermes Reef. This poster reports on the major findings of the surveys with emphasis on invasive plant species that were detected, the role of rapid detection, ongoing monitoring and rapid control of invasive weeds in the NWHI and elsewhere, and recommendations for future invasive plant species work based on lessons learned. On Midway, about 80 species previously not known from the atoll were detected, many of which were highly invasive and restricted to small populations. On Pearl & Hermes Atoll, we documented two highly invasive plant species new to the relatively pristine atoll. Some of the harmful species identified by the survey have already been eradicated.

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## DO EXISTING HARVEST MODELS LEAD TO UNACCEPTABLE RISKS FOR THREATENED SALMON?

The tremendous annual variability of salmon returns seriously complicates any attempt to model the consequences of alternative harvest policies, and may greatly increase the risk of over-harvest. The mathematical theory of optimal sustained harvest in variable environments clearly indicates that, rather than adjusting harvest rates in response to estimates of current returns, the best policy is to adopt thresholds of spawner abundance below which zero harvest is allowed. We investigate the performance of harvest moratoriums under a range of assumptions about how density-dependence may be operating. Our models are tailored to data regarding in-river harvest of Snake River Fall Chinook, a federally listed species. Unlike earlier models, which focus on population size or yield, we use 'risk of extinction' as the primary metric for comparing alternative harvest scenarios. We find that, over the majority of assumptions regarding density-dependence, a policy based on harvest thresholds leads to the lowest extinction risks. Harvest thresholds have never been embraced because it is assumed that they would result unacceptably variable harvest yields. However, we find thresholds may not result in unacceptably variable harvest, especially if yields are averaged over two or three year time periods.

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## HERITAGE CONSERVATION STATUS ASSESSMENTS: AN UPDATE AND A POSSIBLE QUANTITATIVE APPROACH.

The Nature Conservancy's Science Division developed a method in 1982 for evaluating the health and condition of species and ecological communities tracked in the Natural Heritage Network. In common with most systems for evaluating extinction/extirpation risk, Heritage assessments rely on analysis of a set of risk factors such as population size, area of occupancy, threats, and trends. The Heritage system is somewhat qualitative in its approach, giving users flexibility in assessing very different biological entities (e.g., insects, large mammals, and ecological communities) within a commonly used framework. This flexibility comes with costs, including increased variance among assessors evaluating the same data. Recently, changes were made to the coded values used to characterize each of the Heritage risk factors so as to increase compatibility with IUCN Red List assessments. As a result of these changes, it is now possible to develop and evaluate a quantitative approach to Heritage conservation status assessments. This approach, although complicated by the need to specify the range of uncertainty, may permit more rigorous assessments of conservation status in the future. This work is part of a two-year study at NCEAS to develop and test methods for classifying species conservation status and to estimate extinction risk.

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## MANAGING THE EXTINCTION DEBT: THE EFFECTIVE APPLICATION OF *EX SITU* CONSERVATION FOR THE THREATENED HAWAIIAN FLORA.

*Ex situ* conservation has been proposed as a technique to counter biodiversity loss. How effective is this response in retarding or preventing the loss of endemic plant diversity in oceanic islands? We present data on species and population loss demonstrating the catastrophic decline in endemic floristic diversity for Hawai'i. Through selected Hawaiian case studies we critically assess the utility of *ex situ* conservation through examining taxonomic and genetic representation in cultivation, and the effectiveness of *ex situ* in supporting reintroduction and habitat restoration. We also examine the practical role of *ex situ* in the light of recent conservation legislation and the Convention on Biological Diversity. Based on our studies we propose that *ex situ* conservation will play a fundamental role in retaining species diversity otherwise destined for extinction through irreversible habitat loss and exotic species impact. However, practitioners will need to adopt a strategic approach utilizing long term storage technology (seed banking, tissue storage), *ex situ* cultivation and the horticultural management of populations in managed reserves and exclosures.

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## RELATIVE RISKS IN PVA: ACCURACY IN THE FACE OF UNCERTAINTY.

Recent work has demonstrated the uncertainty associated with predicting risks of extinction, drawing into question the usefulness of population viability analysis (PVA). However, the most valuable role of PVA is the ability to predict

relative risks. Therefore, a stochastic Ricker model was used to investigate the reliability of predicted changes in risks of decline in response to changes in parameters, the reliability of ranking species in terms of their relative threat, and the reliability of choosing the better of two management decisions. The predicted changes in risks of decline were more reliable than absolute predictions. Across 160 different parameter combinations, the rank correlation between the true risks of extinction and predicted risks was 0.59 when using 10 years of data, increasing to 0.89 when using 100 years of data. Finally, the better of two management strategies was identified 67-74% of the time using 10 years of data, increasing to 92-93% of the time when using 100 years of data. The results demonstrate that despite uncertainty in the predicted risks of decline, PVA may reliably contribute to management of threatened species.

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MATING SYSTEM PARAMETERS AND EFFECTIVE POPULATION SIZE FOR POPULATION VIABILITY. The Laysan finch (*Telespyza cantans*) is an endangered passerine bird, endemic to the Northwest Hawaiian Islands, whose mating system has long been considered monogamous. However, these birds are sexually dimorphic in both size and plumage coloration, suggesting some frequency of polygyny or extra-pair mating. In fact a polygynous male, along with two females and their nests, was observed in 1999, among one of the translocated populations at Pearl & Hermes Reef (PHR). After extracting DNA from the feathers of more than 200 PHR finches representing about 35 families, I amplified and sized alleles at eight microsatellite loci. The resulting genotypes permit comparison of behaviorally-assigned parentage to genetic assignments, and thus estimation of the frequency extra-pair matings. That information, in turn, leads to more detailed estimates of effective population size and extinction probabilities among the translocated populations.

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IGNORANCE ISN'T BLISS: SUPPLEMENTATION CAN MASK POPULATION STATUS.

Supplementing natural populations with artificially-reared individuals is becoming an increasingly common management tool, used in fish, invertebrate, plant and bird populations. Such supplementation is intended to allow increased harvest or to aid in the re-building of declining populations. However, introducing these artificially-reared individuals (in essence, establishing immigration from another population) can also mask the status of the natural population, making risk assessment or viability analysis for those populations extremely difficult. We constructed a simple, two-population model to evaluate the impact of such masking on estimates of annual population growth rate. Using anadromous salmonids from the Columbia River Basin as an example, we show that even apparently increasing or stable populations may, in fact, be declining, if artificially-reared individuals reproduce at a substantial rate. These results underscore the importance of marking captive-reared individuals, and of maintaining a rigorous monitoring program that assesses the reproductive success of those individuals.

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USING DEMOGRAPHIC AND GENETIC DATA FOR THE CONSERVATION OF *MESPILUS CANESCENS*, A RARE ROSACEOUS SHRUB.

Arguments persist over the relative importance of demography and genetics for the conservation of rare species. In this study, we show how the integrated use of demographic *and* genetic data provides the framework for a plan to rescue an extremely rare plant, *Mespilus canescens*. Also known as Stern's medlar, this species is a multi-stemmed shrub known only from a single population in central Arkansas. The population declined from 29 to 25 individuals over a ten-year period, with no evidence of new recruits being produced. To effectively target plants for collection of germplasm for *ex situ* conservation, RAPDs were used to identify genetically unique individuals present in the native population. Two of the 25 plants in the population were genetically identical (i.e. clones). Genetic diversity for the population overall was low with > 80% of the extant variation found within individuals. Demographic data indicated that *ex situ* propagation of plants would be integral to the management of this species. Using genetic data, we identified unique individuals from which to collect germplasm. This information has allowed us to begin development of an *ex situ* population that represents the totality of genetic variation within *Mespilus canescens*.

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DEFINING RECOVERY FOR PACIFIC SALMON: DO WE HAVE TO BE ARBITRARY?

So far, 26 “species” of Pacific salmonids have been listed as threatened or endangered under the US Endangered Species Act and delisting criteria are required as part of recovery planning. Reviews of existing recovery plans for a variety of species reveal a large amount of arbitrariness in setting delisting criteria. I have developed an approach for biologically based delisting criteria at the demographically independent population level that uses existing time series data to set growth rate and minimum size parameters. The first criterion simply requires a non-negative growth rate [i.e.  $\mu = \text{mean}(\ln(N_{t+1}/N_t)) \geq 0$ ]. However, because of environmental variability, a point estimate of  $\mu = 0$  does not mean that a population has a non-negative growth rate and statistically defensible critical  $\mu$  values must be determined. Data on variance in Pacific salmon populations indicate critical  $\mu$  values must be substantially greater than zero for estimates made on the 10-20 year scale. Minimum size criteria are identified by assuming environmental stochasticity drives extinction risk for a population with nonnegative growth. Minimum size estimates are often in the low hundreds of spawners for a stable population. This relatively low minimum size is probably because of the risk buffering effects of salmon life history.

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#### POPULATION BIOLOGY OF STEELHEAD RAINBOW TROUT: ‘NEW’ CONCEPTS FOR RECOVERY.

Ecological theory and recent evidence from otolith and genetic analyses suggests that California coastal rainbow trout (*Oncorhynchus mykiss*) populations are polymorphic in life-history. However, management and recovery of steelhead, the anadromous life-history form, continue to be guided by management concepts that treat the anadromous forms as discrete populations. Most notable is the decision by the federal government to list only the anadromous forms under the Endangered Species Act. Long-term persistence in highly variable and extreme environments at the margin of the species’ range (which, for steelhead, is most of California) likely requires a polymorphic population structure with multiple life-history strategies and intact linkages between all life-history forms within the population. The disruption of these linkages, primarily due to habitat alteration and dams that isolate non-anadromous populations in perennial headwaters, has led to permanent and widespread extirpations in southern California. Steelhead restoration and recovery strategies must be guided by population ecology concepts such as population persistence in marginal, highly variable environments, polymorphic population structure as it relates to localized extinction and recolonization, and meta-population dynamics. Recovery strategies that focus on restoring ecosystem processes, functions, and linkages are necessary if recovery of depressed populations is to be successful.

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#### INTERACTIVE DECISION-SUPPORT SYSTEM FOR COARSE-FILTER BIODIVERSITY ASSESSMENT.

It is difficult to identify habitats and habitat patches in greatest need of protection, or those that will provide the greatest ecological value for the cost of protection. We have developed a method for quantitatively evaluating biodiversity using a coarse-filter, natural community-based approach and applied this method in western Massachusetts. Our approach involves applying “biodiversity filters” to each point and patch in the landscape. Each filter acts as a lens that allows you to see different aspects of the underlying natural community map, and consists of a model that applies community-specific criteria to the content, context, spatial character, and condition of a point or patch in the landscape to arrive at an index of biodiversity value. Each filter takes input parameters that are supplied separately for each community, and returns a value ranging from 0 (low value) to 1 (high value). Typically, several filters are applied to the landscape and then integrated in a weighted linear combination. Weights are supplied by the user to reflect the relative importance of each filter for each community. This process results in a final “biodiversity value” for each point in the landscape, and is the first step in prioritizing land for conservation.

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#### SEPARATING THE INFLUENCES OF MULTIPLE FACTORS ON BREEDING BIRDS IN THE OREGON COAST RANGE.

Most past studies of habitat fragmentation have merely reported correlations between patch size and species abundance. While these investigations of the ‘area effect’ have framed important questions, they are incapable of answering many of them. To give conservation planning a reliable basis, studies must explicitly separate the effects of several factors which influence bird populations in complex landscapes. Our major goal in this study was to quantify how abundances of forest birds in the Oregon Coast Range are related to vegetation, patch, and landscape factors, and

how these relationships reflect species life-history characteristics. We used partial logit regression and partial canonical ordination to decompose the variance in breeding bird occurrence into components explainable by combinations of vegetation, patch, landscape or spatial autocorrelation factors. By separating these factors, we were able to obtain a comprehensive picture of the relative influence and interaction of these important factors. Finally, we related the results to life-history characteristics of the study species. These associations may facilitate predictions about how habitat changes may affect the bird community. This kind of comprehensive analysis of the factors driving species abundances is essential if we are to clearly understand and effectively conserve wildlife populations in changing landscapes.

MCKENNA, SHEILA A., and Robert H. Richmond. Conservation International, 1919 M St. N.W., Suite 600 Washington, D.C. 20036, USA (SAM), Marine Laboratory, University of Guam, Mangilao, Guam 96923 (RHR). LAND-USE AND CORAL REEFS; ECOLOGICAL LESSONS FROM GUAM.

Establishing marine protected areas is a means of preserving rapidly declining coral reefs. However, major threats to protected reefs can originate on land. Finding an effective way to determine differences in coral reef communities in tandem with land-use practices is important for reef conservation and management. Here we surveyed three coral reef sites adjacent to various land-use areas to see if differences could be detected in community composition through Analysis of Similarity (ANOSIM) comparisons. These sites included a reef adjacent to land with a poorly managed watershed (PMW) and two reference reefs (REF1 and REF2). At all sites, percent cover of reef substrata/biota type was determined by the line intercept transect method. ANOSIM comparisons were used to detect differences among the sites. The PMW site had lower coral coverage, more fleshy algae, and silt in comparison to the other sites ( $p < 0.01$ ). The dissimilarity of reef substrata/biota type between reef sites was 80.5% for PMW and REF1; 78.9% for PMW and REF2; and 32.9% for REF1 and REF2. ANOSIM comparisons are a useful tool for examining community differences between reef sites identified *a priori* and can provide insight into the effect of land use on coral reefs.

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USING MODELS TO SET CONSERVATION PRIORITIES IN THE VALDIVIAN TEMPERATE FORESTS.

The rapid loss of habitat from the Valdivian temperate forests in Chile and Argentina due to conversion to exotic plantations and clear cutting makes it critical that we identify clear conservation priorities that will ensure the long-term viability of biodiversity. We developed a model based on biophysical parameters (rainfall, temperature, soil types, Pleistocene glaciation and volcanism) to map distinct landscape units. Our goal was to represent a minimum of 15% of each landscape unit. We used a socioeconomic model based on existing and developing industry and infrastructure, grazing, fire susceptibility, unimplemented parks, and touristic zones to determine areas of low to high conservation opportunity. We identified 183 distinct landscape units, 141 of which are less than 15% represented by 38 strict protected areas. We recommend a portfolio of additional sites to fully represent all landscape units. We compared our results to a set of priority sites selected by regional experts based on important taxonomic areas to test the use of representation of landscape units as a tool for conservation planning.

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MICROHABITAT USE IN AN ASSEMBLAGE OF NATIVE AND INTRODUCED STREAM FISHES IN HAWAII.

There have been many investigations documenting the negative impacts of introduced species on terrestrial ecosystems in the Hawaiian Islands. Less scientific attention has been focused on understanding the ecological role of alien species in Hawaiian aquatic ecosystems. The introduction of non-native fishes in Hawai'i began as early as 1800 and continues today. Fishes in the family Poeciliidae are now the most widespread and abundant group of introduced fishes in Hawai'i and can be found in most brackish and freshwater systems throughout the state. Little is known about the basic ecology of these non-indigenous fishes in Hawaiian streams where they occur syntopically with native amphidromous gobies. Surveys were conducted in Wailoa stream on the island of Hawai'i to identify patterns of microhabitat use in introduced poeciliids and to compare their microhabitat use patterns with those of the indigenous gobies. Preliminary results indicate that poeciliid fishes in Wailoa stream were selecting microhabitats with lower water velocities and more aquatic vegetation than is randomly available. Multivariate analyses also showed very little

overlap in the microhabitats of poeciliids and gobies. Differential habitat preferences appear to allow poeciliids and gobiids to coexist in Wailoa stream with no competition for spatial resources.

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#### MALE-MALE COMPETITION MAGNIFIES INBREEDING DEPRESSION IN WILD HOUSE MICE.

Inbreeding has well documented negative consequences on animal life-history traits such as growth rate and survival. Unfortunately, these consequences have been measured primarily on juvenile individuals in artificial conditions. We provide direct experimental evidence that competition increases the harmful effects of inbreeding on both offspring survival and reproduction, particularly for males. We compared the fitness of inbred (from full-sibling matings) and outbred adult house mice (*Mus domesticus*) in large, seminatural enclosures. Inbreeding depression was significantly worse in seminatural conditions relative to controlled laboratory matings for males, but not for females. In competitive conditions, the overall reduction in fitness from inbreeding was 57%, which is 4.5 times as great as previous estimates from the laboratory. Inbred females weaned 80% as many pups as outbred females, while inbred males sired only 20% as many offspring as outbred males. The fitness decrease in inbred males was due to decreased competitive ability and survivorship, which were also correlated with an increase in nematode infection intensity in these animals. Our data suggest that reintroduction programs should strive to produce outbred individuals that will be better suited than inbred animals to deal with biotic stresses such as competition or parasitism.

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#### DRYLAND FOREST RESTORATION AT AUWAHI, MAUI.

The native forests of leeward Haleakala volcano, East Maui, were historically considered by many biologists to be amongst the richest of Hawaiian terrestrial ecosystems. Remnants of this forest type indicate its former extents across much of southern Haleakala volcano. This 10-12 meter tall forest, largely replaced by kikuyugrass (*Pennisetum clandestinum*) pasturelands, likely greatly increased the fog interception, ground moisture, and fertility of southern Haleakala. Because of the impacts of ungulates, wildland fires and invasive non-native plants, only approximately 5% of this forest type remains, most of that in the Auwahi district, privately owned by 'Ulupalakua Ranch. In cooperation with the ranch, research is currently being conducted at Auwahi to develop technology for forest restoration using a particularly rich 4 ha enclosure as our primary study site. Our work includes an experiment initiated in January 2000, evaluating the role of mycorrhizae, outplanting site shading, and artificial irrigation in the survival and growth of 1560 seedlings (*Nothocestrum latifolium*, *Ochrosia haleakalae*, *Panicum tenuifolium*, *Pleomele auwahiensis*, *Xylosma hawaiiense*). Based on the survivorship and growth of outplanted seedlings, the continued unassisted recruitment of seedlings within the Pu'u-ouli enclosure, and the sustained levels of enthusiastic volunteer support, we are encouraged at the prospect of forest restoration on leeward Haleakala in the coming decades.

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#### RECOVERING THE FLORIDA PANTHER: HABITAT FRAGMENTATION, CONNECTIVITY, AND CONSERVATION PLANNING.

Southwest Florida is experiencing rapid human population growth and infrastructure development that may hinder recovery of the Florida panther (*Puma concolor coryi*). The landscape is a barrier-rich patchwork of urban, agricultural, and natural areas that is subjected to contentious conservation planning and endangered species management. We used 2 decades of radio telemetry data and ArcView GIS to develop a regional blueprint for landscape restoration that enhances panther dispersal, facilitates population colonization to the north, and that can serve as a tool for future land use decisions in the subspecies' range. A least cost path analysis modeled natural colonization events and may be useful as a planning tool that can be used to identify landscape linkages and conservation networks. Such connectivity is threatened, however, with ongoing development that may not appear in current land use data. Our analysis of permitted, but unbuilt projects suggests that large-scale land protection must happen quickly. The consequence is an isolated population that will require extensive habitat restoration to allow successful recovery.

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#### HABITAT LOSS, SPECIES EXTINCTIONS, AND LANDSCAPE-LEVEL CONSERVATION IN HAWAII.

During the past decade, conservationists have placed increased importance on landscape-level conservation efforts. Such efforts are potentially more efficient and more effective in sustaining both species and ecosystems. The Hawaiian Islands have experienced more extinctions and harbor more endangered species than any other area in the United States. Hawai'i's relatively well-documented flora and avifauna provide a good opportunity to assess how well existing and proposed landscape-level conservation efforts may succeed in maintaining biodiversity. Species-area relationships calculated for the Hawaiian Islands show strong declines in plant and bird diversity as habitat declines. These relationships indicate that the loss of Hawaiian biodiversity will continue into the foreseeable future unless habitat loss caused by alien ungulates, weeds, and pests is halted. Improved management of existing conservation lands and the implementation of landscape-level conservation efforts may significantly reduce species extinctions.

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#### SALAMANDER ABSENCE IN FOREST FRAGMENTS ON THE BLUE RIDGE PARKWAY, USA.

This study tested the hypotheses that salamander species diversity and numbers are greater in continuous forest cover than in forest fragments; and that young stands have fewer salamanders than older stands. We sampled 19 woodlots and continuous forest sites along the Blue Ridge Parkway. No salamanders were detected in any of the woodlots. In contrast, salamanders were detected in all but one of the continuous forest sites. Salamander diversity and numbers increased with stand age.

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#### THE CONSERVATION LEGACY OF ALDO LEOPOLD'S REPORT ON THE HURON MOUNTAIN CLUB.

Aldo Leopold's 1938 "Report on Huron Mountain Club" is a little-recognized landmark in the evolution of Leopold's thinking and the development of conservation ideas. The privately owned Huron Mountain Club along the south shore of Lake Superior has preserved a relatively large (15,000 acres) tract of old-growth forest for over a century. In 1938, Leopold assessed the status of the Club's lands and outlined a vision for their management. Leopold's report offered innovative ideas in forestry (e.g., protection of old-growth forest, selective harvest), game management (reduction of white-tailed deer populations), non-game management (protection of rare and endangered non-game species), and protected area design (reduction of fragmentation, establishment of a buffer zone). Following Leopold's report, the Club enacted a unique and progressive policy that anticipated recent developments in ecosystem management, reserve design, and large-scale integrated land management on private lands. The report allows us to examine the roots of modern conservation concepts, to assess progress in conservation planning, and to evaluate the long-term viability of landscape-scale approaches to private land conservation. The historical connection between Leopold's legacy and the Huron Mountain Club lands also holds lessons for interdisciplinary studies of public land conservation in the U.S. and elsewhere.

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#### SEASONAL OCCURRENCE OF THE ENDANGERED HAWAIIAN HOARY BAT ON THE ISLAND OF HAWAII.

There is disagreement as to whether the Hawaiian hoary bat (*Lasiurus cinereus semotus*) moves seasonally between regions on the island of Hawai'i. To investigate the extent to which bats may be roosting in different regions at different times of year, I conducted presence-absence surveys over a wide geographical and altitudinal range. Also, I examined gender records to determine whether the sexes differ in their patterns of occurrence. Bats exhibited different seasonal patterns of occurrence in the lowlands, eastern highlands, and central highlands. Fluctuations in occurrence suggest that bats (1) move out of the eastern highlands and into the lowlands in April, (2) make a partial return migration to the eastern and central highlands in October, and (3) move out of the lowlands and central highlands to re-invade the eastern highlands in January. Gender data indicate that the partial return migration in October is male-biased. Occurrence was positively correlated with altitude from January to March and negatively correlated with it from April to August, indicating that hoary bats avoid warm winters and cool breeding seasons. That the bat may be differentially roosting in the lowlands and highlands implies its preservation may require the conservation of both low and high altitude habitats.

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#### DATA ISSUES IN NATIONAL LEVEL CONSERVATION PRIORITY-SETTING EXERCISES.

In order to be effective, conservation priority-setting exercises must incorporate biotic as well as physical and socio-economic factors. Digital datasets compiled within a Geographic Information System (GIS) allow the use of gap analysis and other spatial analysis techniques to facilitate conservation priority-setting exercises. In the face of time and resource constraints associated with such exercises, two questions need to be examined: What is the minimum amount of spatial data necessary to conduct such an exercise? What is the status of data availability, quality, and compatibility at the national level? We used such a dataset for India to identify areas of high conservation value and those vulnerable to anthropogenic change, and to highlight gaps in current protection. We also addressed questions related to surrogacy of species richness and endemism data and of species richness data for a variety of taxa. We recommend a more effective clearinghouse for spatial data and stress the importance of metadata.

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#### MONITORING AND MODELING THE EFFECTS OF RESIDENTIAL DEVELOPMENT ON BIODIVERSITY IN OAK WOODLANDS.

Recently, conservation biologists have recognized that continental habitat remnants differ significantly from the island model due primarily to the matrix that surrounds core habitat, making the direct application of island biogeography theory to continental systems questionable. Therefore, it is essential to examine biodiversity in the matrix, in addition to monitoring core habitat across fragmented landscapes. To examine the effects of fragmentation due to residential development, plant and bird communities were monitored at 12 oak woodland sites in Sonoma County, California, one of the fastest growing counties in the state. The sites were evenly distributed across relatively undisturbed hardwood rangeland in private parcels greater than 120 hectares; ranchettes on 4 to 16-hectare lots; and suburban areas divided into 0.20 to 1.0 hectare lots. The level of development was shown to significantly affect the flora and avian community including differences in the number of exotics and presence of neotropical migrants. A rule-based spatially explicit development model was used to examine oak woodland habitat that is likely to be fragmented by varying housing densities in the future. The model and field data predict changes in species composition that may result from future development scenarios in Sonoma County.

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#### EFFECTS OF POPULATION SIZE AND DENSITY ON REPRODUCTION AND GENETIC VARIATION IN WILD LUPINE, *LUPINUS PERENNIS*.

In the past 100 years, *Lupinus perennis*, an indicator species for the imperiled Oak Openings Savanna of the Great Lakes Ecosystem, has declined in distribution and abundance. Declines in plant populations due to habitat destruction and fragmentation can lead to reduced habitat quality, changes in pollinator services, loss of genetic diversity, and inbreeding depression. Observational studies have examined how existing variation in environments and population size and density affect pollination, microsatellite DNA-based indicators of genetic variation, survival, and reproduction. A preliminary study in one population showed significant inbreeding depression. Studies of visitation rates across 5 paired large and small populations documented increased pollinator visitation in dense areas within populations, but rates did not differ significantly among populations varying in size. Experimental studies in progress test for variation in inbreeding depression among populations, while a reciprocal transplant between large and small populations explores the role of population size in the observed patterns. Thirteen microsatellite loci for studies of genetic variation and mating system have been isolated and screened for polymorphisms. These data will improve understanding of the biology of small populations as well as assist in designing management strategies for Lupine and the butterfly species that depend upon it.

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#### INCORPORATING SPECIES INTERACTIONS IN MARINE RESERVE DESIGN.

Marine reserves are often established to manage fisheries and conserve threatened species. However, protecting one species may influence other taxa linked to the target species through predator-prey, competitive or mutualistic interactions. Conversely, efficacy in protecting the target species may depend on the response of the species prey, competitors, or predators. Predator-prey models exploring the effects of different reserve designs show that adding species interactions can generate complex responses to protection, where trophic interactions change not only the magnitude but also the direction of the species response to protection. Thus, species interactions increase the uncertainty about the efficacy of reserves. However, some generalizations may be possible. Using two different modeling approaches, we found that the establishment of marine reserves can cause decline in the prey, followed by a predator decline, for cases of strong top-down control and when the predator has greater dispersal than the prey. A review of empirical data suggests that cascading effects of predation may be more common in shallow hard-bottom systems than in pelagic or soft-sediment systems. Simulations and meta-analysis of monitoring data can help determine the range of possible responses of sets of interacting species to protection, and yield simple rules for reserve design.

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#### HABITAT USE OF THE WORLD'S BIGGEST BATS: ENDANGERED AND ENDEMIC PHILIPPINE FLYING FOXES.

In 1992, the U.S. Navy left the Philippines, and the Subic Bay forest, one of the country's few remaining intact lowland forests, was turned over to the Philippine government. We focused on a roost of over 30,000 endemic and endangered large fruit bats, the Golden Crowned Flying Fox (*Acerodon jubatus*) and the Philippine Giant Fruit Bat (*Pteropus vampyrus lanensis*). Both species are wide ranging and strong ecological interactors in the forest ecosystem. They are also important to local communities culturally and economically and are popular mascots for environmental awareness. No ecological studies have ever been conducted on *Acerodon jubatus* or *Pteropus vampyrus lanensis*. We captured and radio collared twelve fruit bats (5 *Acerodon jubatus*, 7 *Pteropus vampyrus*). Using triangulation, we plotted the resulting 47 fixed locations and visited them on the ground recording the habitat type and measuring them according to structural and vegetative characteristics biologically important to foraging bats. The locations were described as 68.5% in forests, 28.5% in mangroves, and 3% in rural interface for *Acerodon jubatus* and 75% in forests, 17% in mangroves, and 8% in rural interface for *Pteropus vampyrus lanensis*. This habitat use information has already been incorporated into the Subic Bay Protected Area Management Plan.

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#### USING PALEOSHORES TO GUIDE THE DESIGN OF COASTAL PROTECTED AREAS.

Protected areas located within the coastal zone are vulnerable to changes in shoreline position as global sea levels rise. If a given coastal reserve is designed with an insufficient elevation and lateral extent, coastal ecosystems targeted for protection may be unable to migrate sufficiently landwards to avoid submergence. The concept of using paleoshores as markers to guide the placement of coastal protected area boundaries was developed and investigated for this study. Fundamental to this approach is the notion that the marine limit of a modern transgression can be approximated by determining the maximum height attained by sea levels of prior interglacial periods. The coast of Nova Scotia, Canada was assessed for the presence of remnant paleoshores of the Sangomonian Stage (80 000-130 000BP). They were found to occur at an elevation of 4 to 7 metres within four primary regions of the province. By knowing the maximum elevation to which modern sea levels in Nova Scotia will likely rise, the boundaries of coastal reserves within the province can be designed or expanded to buffer protected areas against shoreline migration and coastal flexing.

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#### MAINTAINING GENETIC VARIATION IN AN ISLAND POPULATION: SHORTCOMINGS OF THE ONE MIGRANT RULE.

The view that one migrant per generation will maintain genetic variability in a small population is based on Wright's infinite island model at equilibrium. We employ the analogous continent-island model, but shift the focus to scales more applicable to conservation: the island population over the next 30 generations. On this time scale equilibrium solutions are not appropriate. Mathematical theory and computer simulations are developed to determine how much migration is needed to maintain diversity in the island. It is shown that the short-term trajectory of heterozygosity at neutral loci in the island depends on its effective size, the migration rate and the degree of divergence between it and the continent. When the continent and island were recently panmictic and the island is not large, five, rather than one, effective migrants per generation are necessary to avoid substantial loss of heterozygosity (>5% over 10-30 generations). Migration also benefits allelic diversity, but the benefit is dampened in small populations. When the continent and the island are divergent and/or when the continent is more diverse, fewer migrants are needed. The applicability of our findings are illustrated using the currently isolated Yellowstone grizzly bear (*Ursus arctos*) population.

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#### REEFS OF AN UNINHABITED CARIBBEAN ISLAND: FISHES, BENTHIC HABITAT, AND OPPORTUNITIES TO DISCERN REEF FISHERY IMPACT.

Navassa Island is a tiny (5 km<sup>2</sup>) uninhabited US protectorate located between Jamaica and Haiti. We conducted a rapid assessment of Navassa's coral reef fishes and benthic community structure, to assist in the development of a management plan for the island. The shallow reefs of Navassa (<23m) have high live coral cover (range 20 - 26.1 %) and a high degree of architectural complexity. Despite its remoteness, an active, unregulated artisanal fishery (primarily using traps and hook and line) carried out by Haitians is the primary mode of human impact on Navassa reefs. Even so, shallow reef fish communities exhibit high density (range 97 - 140 fish/60m<sup>2</sup>) and retain representation by large snapper, grouper, and herbivores, which are mostly lacking in nearby Caribbean locations with high fishing pressure. Given the apparently small impact that artisanal fisheries have yet had on its reef communities, Navassa may present a unique opportunity to study the ecological functioning of a trophically intact Caribbean reef. When or if fishing pressures increase, it may be possible to resolve the levels at which the adverse impacts of the artisanal fishery on the reef community become evident, information that would be of utmost value to reef conservation.

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#### USE OF MARK-RECAPTURE ANALYSIS TO QUANTIFY MOVEMENT AND SURVIVAL ALONG FOREST EDGES.

A numerical response to edge could occur because carrying capacity differs across areas, or because edges create source-sink dynamics with preferential movement and survival. Studies of edge effects on mammals have rarely separated these fundamentally different responses to fragmentation. We studied Columbian mice (*Peromyscus keeni oreas*) -- a species that has been posited as being negatively affected by logging -- at replicated sites on the west side of the Olympic Peninsula, WA. We used multi-state capture-recapture models to test whether edges lead to source/sink dynamics such that there are differences in abundance, survival and/or movement probabilities in and among: a) forest-clearcut edges; b) 150 m into clearcuts from the edge; c) 150 m into forest interior. Neither abundance, nor survival, nor movement rates were consistently altered in clearcuts or forest edges relative to undisturbed, mature forest interior. The capture-recapture framework indicated strong temporal variation in capture and recapture probability, emphasizing the importance of using estimators of demographic parameters rather than indices which assume constant detection probabilities. We encourage conservation biologists to make wider use of these new capture-recapture approaches, as they not only quantify detection probability but also facilitate estimates of movement rates that underlie models of spatially structured populations.

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#### EVIDENCE OF INBREEDING DEPRESSION IN ISLAND POPULATIONS OF KOALAS.

Koala populations from South Gippsland, French Island, Kangaroo Island and the Eyre Peninsula are the result of a series of sequential founding events. These populations have significantly less genetic variation than a large natural

population from the Pilliga region ( $p < 0.01$ ). Using these populations we aimed to determine if a correlation existed between male reproductive capacity and a reduction in genetic variation. Significant changes were observed in the sperm head morphology distribution as genetic variation decreased. There is a significant decrease in the number of normal sperm ( $p < 0.01$ ) in the inbred populations and a significant increase in the number of broken necked sperm ( $p < 0.01$ ). There was also a strong correlation ( $R^2 = 0.954$ ;  $p = 0.046$ ) between decreasing genetic variation and an increase in the incidence of testicular aplasia in these populations. Testosterone levels ( $1.4 \pm 0.7$  to  $3.0 \pm 0.5$  ng/ml), sperm motility ( $71 \pm 7\%$  to  $87 \pm 3\%$ ) and sperm volume ( $0.88 \pm 0.1$  to  $1.75 \pm 0.3$ ml) did not vary significantly between populations. The increase in the incidence of testicular aplasia and the changes observed in sperm head morphology distribution are evidence of a loss of reproductive capacity within the inbred populations.

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#### THE PERFORMANCE OF VERTEBRATE INDICATOR GROUPS FOR PRIORITY SETTING IN SUB-SAHARAN AFRICA.

Continental and global scale priority setting is often based on data for a single taxon assumed to indicate the distribution of all biodiversity. We conducted the most extensive large-scale test of this assumption using a database of the distributions of 3882 species in sub-Saharan Africa. Six indicator groups (birds, mammals, amphibians, snakes, threatened birds and threatened mammals) were used to find priority sets of 200 areas that best represent the species in that group. Priority-sets based on a single indicator group represented 83-93% of species in the other groups. However, those species of highest conservation interest were more poorly represented with 75-88% of threatened and 63-76% of narrow-range species being represented in the priority sets. The high degree of representation is consistent with observed high levels of overlap in the patterns of distribution of species in different groups. We conclude that existing priority sets based on indicator groups provide a pragmatic basis for the immediate assessment of priorities for conservation. However, complete and efficient representation - especially of narrow-range species - will not be achieved using indicator groups alone. Therefore, priority setting must remain flexible so that new areas important for other taxa can be incorporated as data becomes available.

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#### INVADER-MEDIATED CHANGE IN GROUND-DWELLING ARTHROPOD BIODIVERSITY.

Non-native plant species are conspicuous features of terrestrial landscapes throughout the world. Although arthropods also dominate these systems, both in terms of biomass and species richness, few studies have considered the consequences of such plant invasions for the composition of arthropod assemblages. Giant reed (*Arundo donax*), periwinkle (*Vinca major*), and poison hemlock (*Conium maculatum*) are three non-native plant species that have invaded extensive portions of riparian habitat in California. Results from a two-year study indicate that overall arthropod abundance was significantly lower in *Arundo* patches compared to other vegetation. Predaceous arthropod abundance was also significantly reduced in *Arundo*, while detritivores increased in *Vinca*, suggesting that predators may be more vulnerable to exotic plant invasion than detritivores. We also examined arthropod response to experimental reductions in *Arundo* stem density. We did not detect an effect of *Arundo* reduction on arthropods after one year, despite the comparative findings discussed earlier. However, we suspect arthropod colonization of this heavily invaded area will eventually occur because 70% of arthropods collected are associated with early succession and disturbance. Findings from these studies will offer the first glimpse of the consequences of exotic plant invasion for arthropod assemblages.

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#### QUANTITATIVE PCR OF DNA FROM NONINVASIVE SAMPLES FOR EFFICIENT MICROSATELLITE GENOTYPING.

Noninvasive samples are commonly used for molecular genetic analyses of wild animal populations. However, the low DNA content of such samples makes DNA amplification difficult, and there is a high frequency of erroneous results where one of two alleles at heterozygous microsatellite loci fail to be amplified. In this paper we describe an assay designed to measure the amount of amplifiable nuclear DNA in low DNA concentration extracts from noninvasive samples. We describe the range of DNA amounts obtained from chimpanzee feces and shed hair samples and formulate a new, efficient approach for accurate microsatellite genotyping. Prescreening of extracts for DNA quantity is recommended for sorting of samples for likely success and reliability. Repetition of results remains extensive for analysis of microsatellite amplifications beginning from low starting amounts of DNA, but is reduced for those with higher DNA content.

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#### EFFECT OF HABITAT FRAGMENTATION BY DAMMING ON THE PERSISTENCE OF STREAM-DWELLING CHARR POPULATIONS.

We assessed the impact of habitat fragmentation by damming on the population viability of a stream-dwelling fish, white-spotted charr (*Salvelinus leucomaenis*), in streams of Hokkaido, the northern island of Japanese archipelago. We determined whether white-spotted charr are extirpated or not in 52 dammed-off sites by electrofishing and snorkeling, and measured five habitat characteristics (isolation periods, watershed area, gradient, altitude, distance from sea). At 52 sites above dams, white-spotted charr were absent in 17 sites and present in 35 sites. Because the charr abounded in all 52 streams below the dams, we could safely assume that damming caused the absence of charr upstream. Among five habitat characteristics examined, stepwise logistic regression analysis revealed that the rate of extirpation increased with increasing isolation period, with decreasing watershed area, and with decreasing gradient. The resulting logistic model explained 82.7 % of the present charr occurrence and forecasted that 12 of 35 extant populations will disappear after 50 years. Our empirical findings imply that extirpation of dammed-off charr populations is inevitable.

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#### PHYLOGENETICS AND CONSERVATION OF HABITATS.

Phylogenies, whether derived from molecular or morphological traits, have been used for a wide variety of analyses relevant to conservation biology, most of which relate to individual species or lineages. Given that protection and management of habitats is the most effective means of conservation, we can ask how phylogenetics, combined with other approaches, can help to identify habitats and areas of high priority and strategies for their management. The major contribution is to improve our knowledge of historical processes that have shaped the diversity of a region, the maintenance of such processes being the primary goal for conservation. Through an understand of process, we should be better placed to extrapolate from our incomplete knowledge of biodiversity pattern when attempting to predict conservation values of areas based on complementarity. These concepts and approaches will be illustrated using the wet tropics rainforests of Australia as an example. Phylogenetic analyses within species and genera reveal a history of long-term vicariance, overwritten by species-specific local extinction, range expansion and secondary contact. Remarkably, preliminary analyses of Phylogenetic Diversity for arthropods, vertebrates and annelids result in spatially congruent priorities. Together with data on species distribution, these analyses suggests conservation priorities for the region based on both pattern and process.

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#### HISTORIC BIRD EXTINCTION ON PACIFIC ISLAND ECOREGIONS: PATTERNS OF BIRD FAMILY, GENUS, SPECIES RICHNESS AND ENDEMISM PRE- AND POST-EXTINCTION WAVE.

Introduced species have caused massive bird extinction on the Pacific Islands, changing the patterns of diversity and endemism. Using islands grouped into ecoregions as our unit of analysis, we mapped the current patterns of family, genus, and species richness and endemism for birds. We then added those bird species that have gone extinct in historical times and compared the patterns pre- and post-extinction. Conservation priorities based on percent endemism have changed due to extinction, with those island groups suffering extinctions declining in conservation priority. We also found that the percentage of threatened bird species is correlated with percentage of extinct bird species, indicating that the island groups that were vulnerable to extinctions in the past are still among the most vulnerable. Thus, the historical trajectory should be considered when developing conservation priorities.

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#### THE EFFECT OF TYPHOONS ON MARIANA CROW PRODUCTIVITY.

We studied the population demographics of the endangered Mariana crow (*Corvus kubaryi*) on Rota from Oct 1996 - Sep 1999. Four cyclonic events were known to directly impact breeding Mariana crows during this period. Twenty-three of 164 nests were destroyed or damaged by high winds associated with these events and, in one instance, caused premature fledging. The most damaging event was Super Typhoon Paka which had high sustained winds (130 kts) and occurred during peak nesting. This storm caused islandwide forest destruction and defoliation, catastrophic nest loss, a truncated breeding season, and mate replacement in two breeding pairs. During the following season, however, the majority of pairs initiated nesting simultaneously and were more fecund. Whereas only one 4-egg clutch had ever been recorded for Mariana crows prior to this storm, seven 4-egg clutches were found during the following season (evidence that productivity is food-limited). We conclude that minor cyclonic events introduce breeding asynchronicity into the population but that major typhoons reset synchronicity. We briefly discuss the stochastic nature of cyclonic events and its consequences on Mariana crow recovery.

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#### FORGOTTEN FAUNAS: SUBOPTIMAL CONSERVATION AND THE NEGLECT OF INVERTEBRATES.

The increasing awareness of inflated biodiversity losses has led to conservation efforts to limit or prevent further declines. Conservation effort however is not evenly allocated across taxa. Invertebrates are typically poorly researched while recovery effort is under-funded. Studies have shown that charismatic factors play a significant role in predicting where effort is focussed. Invertebrates are widely regarded as non-charismatic. A bias against invertebrates can be justified if this optimises the level of biodiversity preserved. Optimisation requires that a particular conservation strategy minimises biodiversity losses for a given set of constraints. Conservation optimisation problems however, are typically unsolvable given the difficulty of assigning values to the benefits from saving species. A further level of difficulty is presented by the dynamic nature of conservation work. This paper presents at a theoretical level, an optimisation rule for conserving species using a dynamic optimisation technique. It is argued that invertebrates have several traits that make them desirable candidates for conservation effort. Hence, if the goal of conservation programmes is to minimise total biodiversity losses, a bias against invertebrates will lead to a suboptimal conservation strategy being pursued. A systematic neglect of invertebrates will lead to greater and potentially avoidable biodiversity losses.

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#### ESTIMATED CHANGE IN POPULATION SIZE, GENE FLOW, AND HYBRIDIZATION OF TWO RARE HAWAIIAN DROSOPHILA SPECIES.

Two closely related Picture Wing *Drosophila* species endemic to the Island of Hawai'i, *D. engyochracea* and *D. hawaiiensis*, are found sympatrically in two mid-elevation kipuka on the S.E. slopes of Mauna Loa. To test the hypothesis that the *D. engyochracea* population has suffered a significant drop in size, we repeated a 1974 mark/recapture study to estimate the population size of *engyochracea*, including *D. hawaiiensis* for comparison. We repeated the study every three months for a total of five collections to examine population fluctuation over the year. Our data shows a dramatic decline in population size since the 1974 study which may be a function of an introduced parasitoid vespula wasp. While there was observable fluctuation in population size over the year, estimates from the most abundant collection period are orders of magnitude lower than the 1974 estimate. Genetic haplotype frequencies and distribution indicate the likelihood of gene flow between the two kipuka, which were previously thought to be isolated. Morphological and genetic data indicate hybridization between the two species in the wild, which in addition to population size declines, may impact on the likelihood for survival of the *D. engyochracea* population.

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#### LONG TERM CONSEQUENCES OF ALDER PLANTATIONS AS AN STRATEGY FOR THE RESTORATION OF TROPICAL CLOUD FORESTS.

Planting trees is a commonly used restoration technique, which assumes that forest recovery is accelerated with respect to natural regeneration. By comparing alder plantations and natural regeneration of equal age in the Central Andes of Colombia we have found the opposite. Plantations yield species-poor forests with little spatial species turnover and a

particular species composition. We explored the mechanisms involved in the observed differences. We found that the presence of alder is associated with a longer persistence of early second growth plant species. This suggests that alder actually slows down succession. Given the type of seed dispersal exhibited by the plants in plantations and forests, we expected differences in seed rain. Seed rain, the main source of plant colonization in the tropics, differed between the two forest types. Although natural regeneration and plantations received the same number of seeds and species, their species composition was different. Differences in seed rain may reinforce existing differences in species composition in the long-term. The results indicate that the presence of alder in the restored forests is likely to leave a permanent imprint on the final product of the restoration.

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#### BREEDING DEMOGRAPHY OF PALILA AND ITS IMPLICATIONS FOR POPULATION RESTORATION TECHNIQUES.

The palila (*Loxioides bailleui*), an endangered finch-billed Hawaiian honeycreeper, is currently restricted to five percent of their historic range (pre-Polynesian contact) due to agricultural clearing, long-term habitat degradation and fragmentation by introduced ungulates, predation by introduced mammals, and avian disease. Removal of feral ungulates has dramatically improved critical habitat, however, palila are responding slowly to forest recovery. Understanding breeding ecology and demography may be crucial to increasing success in reintroductions to historic, recovering habitat. To this end, we began to capture and band all nesting adults in 1999. We documented 19% (17/92) of nesting adults in 1999 and 2000 were at least six years old, including several adults over 10 years old. We suspect only experienced breeders nest in years with limited food resources because breeding effort has fluctuated each year but hatching success (74%±0.03%) and nest success (55%±0.06%) have remained high. The cohort of experienced breeding adults is important to sustain recruitment and productivity in years of scarce food resources.

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#### DISEASE-RELATED AMPHIBIAN DECLINE IN COLORADO, USA.

The recent discovery of a pathogenic chytrid fungus (*Batrachochytrium dendrobatidis*) associated with declines of frogs in the American and Australian tropics, suggests that the proximate cause, at least, may be known for many previously unexplained amphibian declines. Populations of boreal toads (*Bufo boreas*) have declined in Colorado since the 1970s. We have monitored what began as an apparently robust boreal toad metapopulation in Rocky Mountain National Park, Colorado since 1991 at two persistent and two irregular breeding sites. Our objectives were to investigate population processes in boreal toads where a decline was not evident and to provide the Park with information on the status of its resources. However, we observed two significant population declines, first in 1996 and then in 1999. Estimated numbers of male toads peaked at 684 (SE=58) in 1995; in 2000, we observed 2 male and 6 female toads in the entire study area. It appears that this metapopulation is in imminent danger of extinction. Twelve dead and one live toad were collected in 1998–2000 and chytrid fungus was diagnosed in toads collected in 1998 and 2000. Lack of any other apparent cause of mortality makes fungus infection the most likely cause of the population decline.

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#### THE ROLE OF ARTIFICIAL NESTING CAVITIES FOR THE RECOVERY OF THE ENDANGERED HAWAIIAN AKEPA.

Essential niche requirements are necessary for the recovery of endangered species. The Hawaiian Akepa (*Loxops coccineus coccineus*) is the only Hawaiian honeycreeper that nests obligately in natural cavities in trees (ohia [*Metrosideros polymorpha*]) and koa [*Acacia koa*]). Cavities occur mainly in large trees and the average diameter of trees with cavities used by the birds is 1 m. Previous work has shown that geographic variation in density of the bird is related to density of large trees with cavities. A significant conservation problem is that large trees with cavities are

falling at a faster rate than they are being regenerated. For management of this problem, we have developed artificial nesting cavities constructed from 4" ABS pipe. Thus far, seven different pairs of akapa have used cavities successfully and repeatedly. Five additional cavities have had nesting material deposited by other pairs. The combination of successful reproduction repeated over years means that the realized reproductive rate of pairs that use artificial cavities is greater than those that depend on natural cavities that may vary in quality and decompose over time. These cavities thus provide an enhanced niche resource for the recovery of this bird.

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#### EFFECTS OF SELECTIVE LOGGING ON MARTEN (*MARTES AMERICANA*) AND OTHER MAMMALS IN ALGONQUIN PROVINCIAL PARK, CANADA.

Increasing pressure from the growing worldwide demand for wood is being exerted on the remaining coniferous forests of North America. Logging occurs in 75% of Algonquin Provincial Park, Ontario (7600km<sup>2</sup>). The eastern side is predominantly mature red and white pine forests, which are rare in North America. Widespread shelterwood logging is of concern given the abundance of American marten, a species thought to be dependent on mature, coniferous forests. During January-March (2000), we censused tracks of marten and 11 other animal species along seventy-one transects of 2-3 km in length. The transects sampled four logging treatments: uncut forest, young seeding cuts, old seeding cuts and young removal cuts. A Principal Components Analysis showed that moose, deer, wolf and fox were strongly associated with the most recently cut treatments. Snowshoe hare were found significantly more often in the uncut treatments. There were no significant differences in track numbers of marten. Shelterwood cutting may not be as detrimental to marten as clear cutting because canopy cover and dead woody material is present throughout the cut cycle. Further research should examine habitat use in different seasons and after the final removal cut, in which the remainder of the original stand canopy is removed.

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#### COLLABORATIVE INVASIVE SPECIES MANAGEMENT IN HAWAII: THE ROLE OF ISLAND INVASIVE SPECIES COMMITTEES.

Biological invasions of alien species exact a huge toll on Hawaiian ecosystems, agriculture, economy, human health and well being each year. Invaders span ownership boundaries and defy administrative jurisdictions. Additionally, no single agency or organization has adequate resources, authority and jurisdiction to comprehensively deal with invasive species on an island-wide, or state-wide basis. Invasive species committees (ISC's) have been formed on Maui, Hawai'i and O'ahu to collaboratively respond to invasive species and span the gaps in authorities and capabilities of traditional agency lead efforts. The ISC's; 1) provide a forum for public discussion of invasive species issues, 2) prioritize species for management, 3) initiate prevention, early detection, rapid response and sustained control, as needed, 4) facilitate public awareness and education and 5) increase local capacity to manage invasive species across diverse ownerships. The Coordinating Group for Alien Pest Species (CGAPS) serves a similar role at the state level and helps to integrate the efforts of the island ISC's. Comprised of high-level representatives from a diverse group of state and federal agencies and non-governmental organizations, CGAPS increases inter-agency cooperation and effectiveness at a state-wide level and improves public awareness through major media outlets.

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#### ASSESSING ABORIGINAL ENVIRONMENTAL ETHICS.

Discussions surrounding various aboriginal peoples and their environmental ethics have existed from the Romantic period to the present environmental movement. However, these discussions are often unsatisfying, incomplete, and unclear. I contend that this is due in large part to a misunderstanding of the very nature of ethics. While actions can often be understood in light of a professed ethic, and while ethics are one of the things that induce actions, actions and ethics are not coextensive. However, much of the debate surrounding the environmental ethics of aboriginal peoples seems to assume that they are. In this paper I will attempt to clarify the nature of ethics and propose a more accurate method by which to examine various environmental ethics.

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## NUTRITIONAL LANDSCAPE ECOLOGY OF FRUIT BATS IN AMERICAN SAMOA.

Agricultural fruits are nutritionally poor compared to fruits of the native forest. As forests of American Samoa are cleared for agriculture and the demands of a growing human population, fruit bats foraging across the island landscape may suffer nutritionally, particularly for calcium. This study examined whether agricultural or native fruits are preferred by the Tongan flying fox (*Pteropus tonganus*). A habitat map of the island was created to delineate zones of high, average, or low nutrient content. Native forests were areas of high nutrient content, mixed/agroforests were average in nutrient content, and agricultural or urban areas were low in nutrient content. Using radiotelemetry on free-ranging bats, I was able to document use of these three zones as the bats foraged throughout the night. I further examined preference for agricultural or native fruits by performing feeding experiments on captive wild bats. Various fruit combinations of known nutrient concentration were presented to the bats and a strong preference for agricultural fruits was documented. Together, these studies provide insight into bat food choice and help to answer if bats seek out nutrients as they forage across the Samoan island landscape.

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## NESTING SUCCESS OF A HAWAIIAN HONEYCREEPER ALONG AN ALTITUDINAL GRADIENT OF CULICINE MOSQUITOES.

Range reductions, extinctions, and population declines have been documented of Hawaiian honeycreepers (Passeriformes: Fringillidae: Drepanidinae) inhabiting low-elevation forests. One possible explanation for this altitudinal trend in honeycreeper declines is a similar trend in abundance of the introduced night-biting mosquito (*Culex quinquefasciatus*), the primary vector of avian malaria (*Plasmodium relictum*). Experimental infections have demonstrated effects of avian malaria on survival of Hawaiian honeycreepers. Avian malaria could also influence nesting success, by affecting parental effort or nestling survival. We monitored nesting success of 87 Apapane (*Himatione sanguinea*) nests and abundance of *C. quinquefasciatus* between 610 - 1,829 m on the Kona Forest Unit of the Hakalau Forest National Wildlife Refuge, Hawai'i Island, 1998 - 1999. Gravid *C. quinquefasciatus* mosquitoes were captured below each nest over seven trap nights, starting within one week of Apapane nest termination. Mosquito midguts were examined for developing malarial oocysts. No relations existed between Apapane nest fates and mosquito abundance, the proportion of mosquitoes infected with malaria, or elevation. We concluded that 1) the presence of *C. quinquefasciatus* mosquitoes and potential transmission of avian malaria did not affect Apapane nesting success and 2) Apapane populations at low elevations were not limited by nesting success during our study.

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## LARGE-SCALE POPULATION TRENDS FOR GROUND-NESTING BIRDS AND MAMMALS: IS THERE A CONNECTION?

Conservation of vertebrate populations often requires an understanding of the interactions among predators and prey. Recent studies suggest that many mammals are incidental, but important predators of ground-nesting birds. Two large-scale monitoring programs in Minnesota and Wisconsin, USA have detected significant population declines for ground-nesting forest birds and increases for several mammals. Based on breeding bird samples of over 500 forest stands, four ground-nesting birds have declined including three neotropical migrant birds, black-and-white warbler, ovenbird, and mourning warbler, and one short-distance migrant, white-throated sparrow, over the past 10 years. In contrast, based on indices of abundance with scent posts and winter tracking, patterns of increase over the past 20 years have been observed in red fox, coyote, house and feral cats, raccoon, skunk, gray wolf, bobcat, and black bear. Significant declines for the ground-nesting birds are greater than expected by chance for this guild and similar changes have not been observed for species nesting higher in the foliage. Increased populations for mammals is likely due to reduced human persecution, reduced trapping, increased tolerance to human-dominated landscapes, climatic warming, elimination of a top predator (wolverine), possible increased populations of small mammals with increased logging, combinations of these factors, or other factors.

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## CONSERVATION OF HAWAIIAN STREAMS: BRIDGING THE HAWAIIAN PERSPECTIVE AND WESTERN RESEARCH.

The Hawaiian Islands lack indigenous primary freshwater macrobiota, but five species of fishes, two species of crustaceans, and two species of mollusks are ubiquitous among windward streams on high islands in the southeastern section of the archipelago. These amphidromous biota have a marine larval phase, and adults are largely limited to fresh water. The animals exhibit striking species specificity when occupying streams with different topographies, in the instream distribution of adults, habitat selection, food and feeding, reproductive behavior, and migratory patterns of larval and postlarval animals. In spite of diversity in behavior and ecology of Hawaiian stream animals, three policies adopted by the Hawai'i Division of Aquatic Resources have ensured the conservation of all native stream species: (1) Water-use decisions must be based on the principle of no-net loss of habitat for stream biota, (2) the connection between fresh water and the ocean must be maintained for migrating animals, and (3) the ahupua'a or ecosystem approach must be used as the guiding principle to bridge the marine and mountain habitats.

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## EFFECTS OF AN EPIDEMIC OF *MYCOPLASMA GALLISEPTICUM* ON REPRODUCTIVE SUCCESS IN HOUSE FINCHES.

Long known as a pathogen of poultry, *Mycoplasma gallisepticum* (MG) began infecting house finches in 1994. The disease rapidly spread throughout the eastern U.S. and Canada, and was associated with debilitating disease and high mortality in house finches. In recent years, however, the proportion of infected finches dying as a result of infection with MG seems to have declined, and asymptomatic infection is now more common among wild birds than in the past. We document MG infections in breeding house finches and confirm that adults of both sexes transmit the infection to dependent young, probably after hatch. MG infections of breeding adults occurred late in the breeding season, and were found in birds completing significantly more nests than birds that never tested positive for MG, implying that higher rates of reproduction carry a cost in the form of increased risk of infection. We find evidence of an MG-induced delay in dispersal of nestlings from their natal area, and demonstrate a significant impact of MG infection on nestling growth. We conclude that even though finches are now able to breed while infected with MG, the infection may still impose potentially serious limits on reproductive success.

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## HUMAN MOBILITY, BIODIVERSITY ISLANDS AND CONSERVATION IN AUSTRALIA.

The impact on biodiversity of European occupation of the Australian continent in 1788 is often portrayed as significant, but patchy at a regional scale. Many ecosystems have been destroyed or highly modified in southern Australia, whereas much of northern Australia is often described as relatively pristine since it continues to support a relatively undisturbed overstorey vegetation. However, new data and reconsideration of earlier information suggests that the indirect impact on biodiversity has been much more pervasive. Even the biodiversity of remote desert and tropical ecosystems with a low human population density has declined significantly. Today, fewer than ten continental landscapes support extensive ecosystems that appear to be relatively intact and pristine. These landscapes or biodiversity islands are exposed to many threats including increased human mobility and visitation as a result of an expansion of tourism to support regional development. My study of the east Kimberley region, Purnululu National Park and western Tanami Desert in Western Australia demonstrates a major increase in human visitation and resource use during the 1990s that threatens biodiversity. Regional development strategies and regional tourism must include adequate and enforceable biodiversity conservation measures to safeguard these islands and related ecosystems.

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## ESTIMATING SPATIAL AND TEMPORAL INTERACTIONS FOR POPULATION VIABILITY ANALYSIS.

Population viability analysis requires the assessment of both spatial and temporal variation of demographic and genetic processes. In addition, the interaction of space and time may also have a significant impact on population processes. Unfortunately, this interaction is rarely considered explicitly in population viability models. This appears to be the case because of the difficulty of obtaining replicate samples at an appropriate temporal scale. We collected replicate samples (temporal and spatial) of eastern mosquitofish from a reactor cooling reservoir on the Savannah River Site. All

fish were sexed/aged, measured for total length and scored for genetic variation at six polymorphic loci. The proportional representation of sexes in populations was primarily explained by the interaction of time and space. Age distribution was primarily a function of spatial distribution of populations. Genetic variation differed between juveniles and adults. Most variation was due to the main effect of time in adults but by the interaction of time and space in juveniles. This has implications for modeling efforts of endangered species in that an important component of variation, the interaction of time and space, is usually relegated to the error term, thus reducing the power of the analysis.

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#### IMPROVING PUBLIC PARTICIPATION IN HABITAT CONSERVATION PLANNING: A CALIFORNIA CASE AND LESSONS.

A trend in endangered species conservation is toward collaborative regional Habitat Conservation Plans (HCPs). HCPs seek conservation and compatible development. California's Natural Community Conservation Planning (NCCP) program and San Diego's Multiple Species Conservation Plan (MSCP) are examples. In the MSCP case, a citizen's advisory group contributed to the conservation planning process for the rare coastal sage scrub community in an urban center. I summarize research on the MSCP's public outreach and education, with a focus on sustained public participation. Results showed that participants viewed the public as the least knowledgeable but most important audience to reach; nonetheless, they did not seek improved public participation in planning or in implementation. Participants seemed to "fear" too much participation. This poses a problem: how can the public become knowledgeable enough to aid conservation if the core participants prefer to limit the public's participation? To address this problem, I suggest, first, that authorities clarify their goals for public outreach and education. Second, I propose a project steering committee design be employed which includes key public opinion leaders to serve as intermediaries. These two recommendations can aid HCPs by enlisting effective public understanding and financial support for actually meeting HCP goals.

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ROAD SPEED, ELECTRICITY, AND DOGS MAKE FOREST FRAGMENTATION EVEN MORE DANGEROUS FOR THREATENED COLOBUS MONKEYS IN DIANI, KENYA.

Increasing fragmentation of the forest canopy compels the Angolan colobus monkey to traverse dangerous open ground to access favorable forage. *Colobus angolensis* spp *palliatu*s, is an obligate folivore restricted to isolated forest fragments in the south coast of Kenya. With an estimated population of fewer than 1,500, this species is already endangered in Kenya, however, growing settlement within the monkeys habitats threaten it further and habitat loss is estimated at 7.5% per year due to expansion of the tourism industry. A sub-population of 407 individual monkeys living in the densely settled tourist center of Diani have been monitored since 1997 to identify threats and to find solutions. Between August and November 1997, 21 of these monkey were killed by vehicles as they attempted to cross a road. Monkey bridges significantly reduced road mortality, however, new threats have been identified. Seventy-two births were reported over a 20-month period, while mortality of 54 individuals was documented over the same period. Humans were responsible for 76 % of this mortality, all indirect effects of growth in the high-income tourism related sector; electric shock on power cables and attack by security dogs. Local low-income settlements did not pose a significant threat to the species.

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#### INSECT-PARASITISM AND THE CONSERVATION OF AN ENDANGERED BIRD SPECIES ON MAUNA KEA, HAWAII.

Like much of Hawai'i's native fauna and flora, Hawaiian Lepidoptera (butterflies and moths) have been challenged by competition and predation by alien species. Since 1900 over 500 documented releases of predators and parasitoids have been made against insect pests. There are likely many more that were released inadvertently or as clandestine control efforts. Some of these insects now prey on native species that provide food to vertebrates and other invertebrates. As an example, caterpillars in the genus *Cydia* (Tortricidae) were parasitized by four wasp species, three apparently of foreign origins. Wasp species showed differential rates of parasitism depending on elevation, ranging from 94% at 1800m to 21% at 2700m. Likewise, two wasp and one fly species parasitized 57% to 25% of caterpillars in the genus *Scotorythra* (Geometridae) from 2200m to 2800m elevation, respectively. These endemic caterpillars represent an important food resource to palila, an endangered bird species on Mauna Kea, Hawai'i. It is likely that

these alien species, already present for 100 years, will remain a part of this system for some time to come. Sustaining vital components of an ecosystem in the presence of alien parasitoids remains one of the great challenges of island conservation.

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#### USING A POPULATION MODEL TO CONSERVE THE OVEREXPLOITED MADAGASCAR RADIATED TORTOISE.

The radiated tortoise (*Geochelone radiata*), endemic to southern Madagascar, is vulnerable to extinction primarily due to overexploitation. Many tortoises are illegally harvested for meat and pets. However, the geographical extent of the exploitation and rate of extirpation of tortoise populations has not recently been assessed. Tortoise abundance and rate of exploitation of tortoise populations were determined using biological and anthropological techniques in southern Madagascar. These data show radiated tortoises are at low abundance or absent throughout most of their former range and exploitation is more widespread and rapid than previously thought. A tortoise population is more likely to be exploited when proximal to cities, to main roads and to the coast. These variables were incorporated into a spatially explicit harvest model which was used to predict the probability of a population being harvested, and time to extinction, for different tortoise populations in southern Madagascar. This model was then used to identify the tortoise populations which it will be most efficient to try to protect, i.e. lowest probability of being harvested, and where will be best to release confiscated tortoises, given the risks of introducing disease and genetic mixing.

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#### SERAM COCKATOO: BACK FROM THE BRINK OR DID SOMEONE CRY WOLF?

Seram Cockatoos (*Cacatua moluccensis*) are endemic to the Indonesian island of Seram and have been traded for centuries. In response to concern about over-exploitation, the Seram Cockatoo was placed on CITES Appendix I. We addressed whether this cockatoo is on the brink of extinction and if illegal trade is contributing to a population decline. We surveyed 7 sites from May through September 1998 using standard line transects and vegetation plots to estimate cockatoo populations and evaluate habitat. We used GIS to determine forest cover, land use classification and sources of land use conflict, and interviewed hunters and traders. We estimate the population density at  $7.87 (\pm 1.98)$  birds/km<sup>2</sup> in lowland forest and a minimum population of 57,000 birds. Abundance was correlated with the density of favorite nest trees, *Octomeles sumatranus*, and the density of strangling figs. Densities are highest in primary forest with good forest structure, and lower in logged sites. Nearly 50% of Seram is held within logging concessions (8,271 km<sup>2</sup>). Lowland forest, unoccupied by concessions, amounts to 5,096 km<sup>2</sup>. At present, habitat loss is not a serious threat to cockatoos. Although illegal trade continues, the original CITES listing may have been inappropriate and based on little data.

O'CONNOR, RAYMOND J. Department of Wildlife Ecology, University of Maine, Orono, ME 04469-5755, USA. POPULATION LIMITATION IN BIRDS: ISLAND AND MAINLAND CONTRASTS,

Since bird populations on islands are both restricted in area and are in a generally less seasonal environment, greater density-dependence and more frequent population saturation are expected (Newton's hypothesis). Combining this with Ashmole's hypothesis (less migrancy in aseasonal environments) leads to the prediction that migrant species on islands suffer differentially under interspecific competition from resident species. I tested this by collating analyses of long-term national and regional population data from Britain and from the conterminous United States, and compared national population dynamics in Britain against regional population dynamics in the U.S. Greater density dependence was evident in Britain than in equivalent areas of the U.S., both in Taylor Power Law exponents and in direct measures of density dependence, and was commoner in the more numerous resident species than in migrants. In Britain migrant productivity and recruitment was inversely proportional to resident abundance due to competition for preferred habitats. In the United States migrant species were disproportionately numerous by comparison to Britain and biophysical factors dominated habitat factors as constraints on their distribution and abundance. Physical limits to population size in insular birds are thus realized at island sizes far larger than hitherto appreciated in conservation science.

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DEMOGRAPHY OF THE THREATENED SOUTHEASTERN BEACH MOUSE (*PEROMYSCUS POLIONOTUS NIVEIVENTRIS*) AT ITS LAST STRONGHOLD.

Population estimates of the southeastern beach mouse (*Peromyscus polionotus niveiventris*) have not been determined in nearly two decades, and current population measures were needed to facilitate conservation and management of the remaining populations. For this purpose, demographic data were collected on four grids at Cape Canaveral Air Force Station (CCAFS), Florida, the southeastern beach mouse's last stronghold. Six hundred and thirty-nine individual beach mice were recaptured on 1,069 occasions. Sex ratios were close to unity on grids LC2529 and LC17 but showed more deviation at grids AQ and JETTY, significantly so at grid JETTY. Adults dominated the captures on the grids, followed by subadults and juveniles. Reproductively active males and females were observed in all seasons on the grids but were most prevalent in fall. JETTY and AQ, the two southernmost, grids showed similar patterns of increases and declines in population size over the course of the study. LC2529, the largest grid, exhibited continued increases in population size until Summer 1997 when a decline occurred only to be followed by a peak in Fall 1997. LC17, the northernmost grid, showed less variation in beach mouse abundance and resembled JETTY and AQ more than LC2529 in this regard.

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BIGHORN SHEEP IN MEXICAN INDIAN LANDS: SUSTAINABLE DEVELOPMENT, CONSERVATION AND ECOLOGICAL EFFECTS ON TIBURÓN ISLAND, SEA OF CORTEZ, MEXICO.

The Bighorn Sheep Management and Sustainable Development Program has had important benefits for Seri Indians, owners of the land. It has produced close to 1 million dols. for this group and their commitment for conservation is now firmly established. The diet and habitat overlap between the introduced bighorn sheep (*Ovis canadensis mexicana*) and the endemic subspecies *Odocoileus hemionus sheldoni*, were evaluated as a measure of niche overlap. The study area was Tiburón Island. For diet analysis and vegetation evaluation, feces were collected, Canfield lines used over two years in 10, 200 m. long transects (5 on plain terrain, and 5 on mountainous). Our analysis shows that there is an overlap in the diet of both species in those plant-species only found in the mountain transects while minimal diet overlap is shown in the plains. After the introduction of 16 bighorn sheep specimens in this area, the population has grown exponentially. No negative impact has been recorded on native species, however is important to monitor both populations and their relationships. It is clear that sheep in the Island have provided an example for successful, socially-oriented conservation however we need to continue monitoring the potential impact of exotic species in protected areas.

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OCEAN ZONING: REPORT OF A SYMPOSIUM SESSION ON DESIGNATED USE AREAS IN THE COASTAL OCEAN.

This paper reports a session on ocean zoning at the 2<sup>nd</sup> Symposium on Marine Conservation Biology in June 2001. In the past few decades, marine protected areas have been implemented all over the world. A particular type of protected area, the fully protected marine reserve, prohibiting fishing and extractive uses, has captured the imagination of policy makers, resource managers, scientists, and the general public. While this is deserving of support, the fully protected marine reserve is only one type of zone and should be implemented within a framework of designated use areas. The Exclusive Economic Zone (EEZ) is a logical, legally defensible, and ecologically meaningful area in which various designated use areas can be implemented with the best chance to achieve a sustainable balance of resource use and conservation. Drawing upon case studies including the Great Barrier Reef Marine Park, the Florida Keys National Marine Sanctuary, the Gulf of Maine, and various international marine ecoregional plans, this paper will highlight the legal, economic, and ecological background of ocean zoning. Ocean use planning at the scale of the EEZ demystifies the oceans and lends itself readily to phased implementation, partnerships with coastal states and nations, and public participation and education.

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#### THE COST OF HUMAN DISTURBANCE: DIFFERENCES IN ECOLOGY AND BEHAVIOR OF THE BLACK HOWLER MONKEY IN BELIZE.

When comparing “pristine” primary growth and human-altered secondary habitat in northern Belize, I found noted differences in the ecology and behavior of the black howler monkey, *Alouatta pigra*. Habitat, population and behavioral data from a secondary forest were collected at Lamanai (L) (a 385-ha archaeological reserve) over a period of 2 years. I conducted a recent study at Irish Creek (IC), a protected 375-ha block of varying seasonal old growth forest, which provided habitat for 25 troops of *A. pigra* (22 at L-site). Activity budgets at both sites were similar for most behavioral categories, however significant differences were found in proportion of time spent vocalizing (IC-13%; L-4%) and traveling (IC-9%; L-15%). I also found that average troop size and range in troop composition was higher at IC (6.2 individuals; range 1-18). In IC, troops also existed with multiple adult males, which is rarely documented for *A. pigra* in secondary habitats. This may be due to higher resource availability and natural predation. The changes in ecology, social structure, and behavior of *A. pigra* residing in habitat highly impacted by humans represent important concerns for the future protection and conservation of this species.

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#### FAUNAL VARIATION AMONG FISH MICROREFUGIA IN KENYA'S LAKE VICTORIA BASIN.

Much of what remains of Lake Victoria's indigenous fish species flocks survive in small, vulnerable water bodies scattered about the lake basin. The viability of these refugia is in question, and a strategy for long-term conservation must be devised. Seine surveys of fish distribution and abundance patterns in 14 small (mostly artificial) lakes in Kenya revealed surprising variation in species composition. Eight lakes in North Nyanza were dominated by lacustrine cichlid species, while cyprinids and catfishes were more prevalent in six lakes in South Nyanza (ANOVA on N/S canonical axis  $P=0.001$ ). Northern lakes were refugia for *Lipochromis maxillaris* (endangered), *Xystichromis phytophagus* (threatened) and *Oreochromis variabilis* (threatened). Southern lakes harbored seasonally landlocked *Labeo victorianus*. Small water bodies vary widely in their potential as species refugia, and are greatly influenced by rainfall and human activities. Collectively small water bodies may be regionally significant as refugia for some of Lake Victoria's surviving endemics, but no lake stands alone as a conservation panacea.

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#### BUILDING A CONSERVATION VISION FOR THE MESOAMERICAN REEF ECOREGION.

Conservation visions define what success should look like after several decades, based on what the best available data and biological insights indicate. They map proposed representative systems of conservation areas of sufficient size, condition, and connectivity to maintain even the most sensitive species and ecological processes. We asked 80 regional experts at a workshop (May 2000) in Mexico to help build a foundation for a conservation vision for the Mesoamerican Reef ecoregion by addressing representation issues and the requirements for persistence of species and ecological phenomena. Experts identified important areas for different taxa and priority areas for biodiversity conservation, in general. A future network of marine protected areas that 1) represented distinct communities and habitats, and 2) allowed for persistence in the face of hurricanes, sedimentation events from watersheds, and pervasive fishing was proposed.

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#### RECOVERY AND CRYOPRESERVATION OF GERMLASM IN RARE AND ENDANGERED SPECIES.

The collection and cryopreservation of genetic material is a valuable way to preserve an individual's as well as a population's genetic diversity, which is critical for the conservation of endangered species. The Zoological Society of San Diego maintains the Frozen Zoo ® which includes both fibroblast cell lines and germplasm from 375 species including mammals, birds and reptiles. Blood and tissue samples from both captive and wild individuals are collected during medical procedures or at the time of death. The germplasm repository within the Frozen Zoo ® includes sperm, oocytes and embryos from 268 species, 58 of which are endangered. Collection and cryopreservation techniques are

developed for each species to maximize post-thaw germplasm viability. Samples are stored in liquid nitrogen until needed for assisted reproductive procedures such as artificial insemination or in vitro fertilization. These procedures enhance diversity of captive populations by infusing genes from other remote captive animals or from free-ranging specimens. Recent emergent technologies in genomics and reproductive biology demonstrate the importance of such a collection. As a crucial resource for research and conservation, it provides new opportunities for linking field and laboratory conservation.

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#### COMBINING CENSUS AND DEMOGRAPHIC DATA TO ASSESS THE VIABILITY OF AN IMPERILED TIGER BEETLE.

Population modelers have nearly despaired of precisely estimating extinction risk, yet the predicaments of imperiled species and those who are trying to protect them remain. While we should be realistic about the precision attainable in population modeling, we also should use all available information to assess the viability of imperiled populations. Here we present studies of the federally threatened Puritan tiger beetle to illustrate an approach to assessing population viability that uses both census data and directly measured demographic rates. We fitted a population model to the census data to generate one set of parameter estimates. A second set came directly from our measurements of larval survival and interpatch movement, as well as published values of other demographic rates in related species. Finally, we estimated the parameters using both data sources in combination by fitting the population model to the census data using the directly measured demographic rates as prior probabilities. Simulations based on the estimates from the combined approach yielded qualitatively similar predictions to those based on either data source separately, but with greater precision. We conclude that Puritan tiger beetles on the Connecticut River do not face a significant risk of extinction within the next 25 years.

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#### METAPOPULATION DYNAMICS AND GENETIC VARIABILITY OF “ISLAND POPULATIONS” OF BLACK BEARS.

The recolonization of former range by large carnivores is a rare and prolonged process. Such an event is further impeded within ecosystems that are naturally fragmented, such as the Chihuahuan Desert. Black bears (*Ursus americanus*) have recently (~1988) recolonized portions of western Texas purportedly via migration from larger “mainland” populations in northern Mexico. To determine the number of haplotypes, genetic diversity, and divergence within this southwestern clade of black bears, we examined mitochondrial DNA (mtDNA) from 46 tissue samples collected from 2 populations in Texas (Big Bend National Park [BBNP] and Black Gap Wildlife Management Area [BGWMA]) and 3 in northern Mexico. Populations are composed of 1-3 haplotypes defined by 2 variable nucleotide positions. Within population haplotypic diversities were generally moderate while nucleotide diversities were low. Analyses suggest a high degree of genetic structure ( $F_{st}=0.503$ ) between populations. Maternal lineages present in BBNP and BGWMA are similar to those within several of the Mexican populations. These data will have management implications in determining the conservation measures necessary to insure the complete recovery of the black bear in western Texas, and provide insight into the metapopulation structure of carnivores in the “sky islands” of the American Southwest.

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#### MONITORING THE ROCKY INTERTIDAL WITH HIGH SCHOOL STUDENTS AND OTHER VOLUNTEER GROUPS.

We are developing site-specific protocols of the rocky intertidal of central California that can be used by high school students and other volunteer groups for long-term monitoring. Vertical transects establish zonation patterns that would change as sea level changes. Abundance and sizes of important species (e.g., owl limpets and sea stars) will detect recruitment and mortality patterns. An interactive website with the data will be maintained by the Seymour Marine Discovery Center. Data collected to date compare favorably with those collected by professional researchers, giving us confidence that the program will (1) introduce students to the rich biota of the rocky intertidal and how to study it, and

(2) provide data that can be used by scientists and resource managers to track long-term changes in this spectacular habitat. Supported by California Sea Grant and the Monterey Bay National Marine Sanctuary.

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#### PERSISTENCE OF CALIFORNIA GNATCATCHERS (*POLIOPTILA C. CALIFORNICA*) IN "OLD-GROWTH" HABITAT DURING A POPULATION CRASH.

The California gnatcatcher (*Polioptila c. californica*), a federally threatened subspecies numbering 1000-1500 pairs in the U.S., is restricted to remnant patches of coastal sage scrub in southern California and northern Baja California. This plant community is variable in its species composition and structure, and gnatcatchers are not evenly distributed throughout. This fact, coupled with year-to-year fluctuations in gnatcatcher population size makes it difficult for habitat managers to assign conservation priorities to different areas of scrub. This preliminary analysis was aimed at clarifying the dynamic between habitat recovery after fire and use of areas by gnatcatchers. Gnatcatcher numbers declined by about 70% between 1999 and 2000 due to factors unrelated to habitat loss. Of 303 territories identified during 1999 and 2000, the majority were located in areas burned 17 or more years previously. There was a significant difference (likelihood ratio chi-square,  $P = 0.002$ ) between 1999 and 2000 in the relative occurrence of territories in fire age classes Old (>15 years since last fire), Middle-aged (years since last fire < 15 and > 8), and Young (> 7 years since last fire), with the largest deviation from expected resulting from few territories being found in Young habitat during 2000. The disproportional persistence of pairs in stands of older habitat during a year when the population crashed may provide the strongest evidence to date that differences in habitat quality have an important influence on the species' population dynamics.

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DEVELOPING APPROACHES TO THE MANAGEMENT OF ELEPHANT POPULATION IN WEST BENGAL (NORTH) FOR MITIGATING MAN-ANIMAL CONFLICTS.

The habitat utilisation pattern of elephants in the present study showed around 70-80% utilisation of forest areas as compared to 20-30% non-forest areas and indicates that habitat preference for elephants are in order of Dense mixed (47.0%), Open mixed (15.1%), Grassland (9.6%) and Dense sal (0.6%). However, dense mixed forest are limited in extent as various commercial plantations have replaced most of them. Most conflicts of elephant in north Bengal takes place either in Tea gardens or in crop fields and information has been collected from records of tea gardens, forest department and also through the radio-collared elephants. Year-wise incidences of conflicts have progressively increased from 1994 to 1996. Tea gardens act as movement corridors for elephants and conflicts happen when elephants use these movement corridors. Most of incidences are due to the involvement of family herds rather than the individual males. Most of the crop raiding incidents fall between Teesta river and the Torsa river where habitat fragmentation is extensive. The severely affected areas are Teesta chaur, Apalchand and Moraghat, to the west of Teesta, the Panighata range is affected severely while to the east of Torsa river severely affected areas are Kodalbasti range, Nimati and Kumargram areas.

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#### UNDERLYING PROCESSES OF FRAGMENTATION IN THE BRAZILIAN ATLANTIC FOREST: INSULARIZATION OR EDGE EFFECTS?

Island Biogeography, which predicts insularization effects through colonization rates (distance among patches) and extinction probabilities (patch size), has been widely used to interpret empirical results and to guide conservation. Recently, however, importance of edge-induced habitat changes in fragments has come to light, and hence the need to distinguish insularization and edge effects. Significantly, both predict a patch-size effect. We studied 24 forest sites in Atlantic Forest remnants of north-eastern Brazil. Forest sites included fragments (<100 ha) and controls (>1000 ha), and within each, edge and interior sites (<20, >100 m from edge). We used partial redundancy analysis to investigate the importance of local habitat structure *versus* size/isolation of fragments to small mammals. Vegetation structure was the only significant gradient in the model. As expected under edge effects, vegetation variation among edges and interior of fragments predicted the small mammal structure of control sites. Using a two-dimensional surface integral edge model, we show that small mammal variation is explained by changes in vegetation structure caused by edge

effects, and estimate the depths of edge effects for vegetation and small mammals. Results show that edge effects penetrated long distances (330 m) and highlight the importance of managing edge processes in fragmented landscapes.

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#### SPATIAL MODELING TO AID IN INSTREAM FLOW DETERMINATION FOR NATIVE HAWAIIAN STREAM FISHES.

In the Hawaiian Islands, the diversion of stream water for agriculture has been common during much of the past century. Yet recently, with the decrease in large-scale sugar cane farming, an increase in overall human population, and a growing awareness of the needs of Hawai'i's native stream fauna, there is a change occurring in the allocation priorities of this diverted water. A spatial model is being developed in a Geographic Information System (GIS) to aid in the difficult process of determining appropriate instream flow standards. To incorporate both the dynamic nature of Hawaiian streams and the amphidromous life cycles of the native stream fishes, the model uses a spatial hierarchy to integrate scale-dependent ecological processes with site-specific data. Three-dimensional models of the islands, watersheds, streams, stream reaches, and sites show the changes in the amount of fish habitat in response to changes in water discharge levels. The use of GIS stream models also allows integration with models in forestry, agriculture, and urban planning that may lead to a more integrated picture of resource use and enhance biodiversity conservation.

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#### GENETIC DIFFERENTIATION AND PHENOTYPIC PLASTICITY IN INVASIVE MULLEIN: FROM SEA LEVEL TO THE HIGH SIERRA.

An important question about the population biology of invasive species is whether those species that successfully invade a wide range of habitats do so because they have high levels of phenotypic plasticity (Baker's "general purpose genotype") or because they rapidly adapt to new environments. Common mullein (*Verbascum thapsus*) occurs in California from sea level to the Sierra Nevada, and appears to be expanding its range upward. We collected seeds from maternal plants in 10 populations ranging from 20 m to 2300 m. Offspring were grown in a common garden and in growth chambers kept at cold and warm temperatures. We found no significant differences for UV reflectance, an important trait at high elevations. We also found no genetically-based differences among populations for growth rates in cold vs. warm temperatures. We did find differentiation for frost tolerance as measured by fluorimetry; however, there was no simple relationship between frost tolerance and increasing altitude. We found strong evidence of a tradeoff in frost tolerance for plants grown in cold temperatures vs. frost tolerance when grown in warm temperatures. However, overall the success of common mullein across its tremendous altitudinal range appears to have little to do with rapid local adaptation.

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#### REPATRIATION OF THE WYOMING TOAD, *BUFO BAXTERI*: A COMPARISON BETWEEN WILD AND CAPTIVE-RAISED ADULT HABITAT USE IN THE WILD.

The Wyoming toad, *Bufo baxteri*, is a critically endangered species endemic to the Laramie River Basin, Albany County, Wyoming. In 1994, they became virtually extinct in the wild when the Wyoming Toad Recovery Group brought the last six adults into captivity. Since 1988, the group has been releasing captive raised toads only in the form of tadpoles and metamorphs retaining adults for breeding. By 1999 there was a surplus of captive-raised adults and 125 toads were released into the wild. To measure the success of this cohort in the wild, we implanted 10 individuals with transmitters. We sampled habitat variables and measured movements from August through November 1999. We compared the results with eight wild adults transmitters at the same site. Captive-raised adults used habitat further away from the lakeshore with significantly denser vegetation than wild adults. Although captive-raised adults moved distances similar to wild adults, we found them to be inactive much of the day indicating that their movements were probably short bursts compared to wild adults that were active throughout every day. Captive-raised adults used habitat much more liberally than wild adults. The captive-raised adults' sporadic movements resembled that of other animals transplanted as adults into new environments.

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## INVESTIGATING POTENTIAL EFFECTS OF PESTICIDE EXPOSURE IN THE RIO GRANDE LEOPARD FROG.

Worldwide population declines and widespread discoveries of deformities in ranid frogs highlight the need for research on the effects of environmental contaminants on this group of amphibians. Populations of the Rio Grande leopard frog (*Rana berlandieri*) were studied in South Texas to gather information on the impact of exposure to insecticides (pyrethroid, organophosphate, and carbamate) and triazine herbicides. I collected frogs from five locations: the (1) Santa Ana and (2) Lower Rio Grande Valley National Wildlife Refuge complex; (3) near Falfurrias, TX; (4) a privately owned ranch in South Texas; and (5) Big Bend National Park. Sites were considered to be of varying pesticide contamination levels due to agricultural chemical applications in South Texas, with the least contaminated site located in Big Bend. During 2000, adult frogs (8 per site; four males and four females) were collected twice from each site (Feb./March and Oct./Nov.) and assessed for gross external and internal abnormalities. Blood plasma, tongue, and liver tissue were collected for reproductive hormone, cholinesterase activity, and pyrethroid residue analyses, respectively. Reproductive tissues were analyzed histopathologically for abnormalities. Results of all analyses will be compared between collection sites to assess the impacts of agricultural-use pesticides on this frog species.

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## RAPID ASSESSMENT OF FAUNAS FOR ECOSYSTEM MANAGEMENT IN WESTERN FOREST COMPLEX IN THAILAND.

The Western Forest Complex with an area of 18,000 km<sup>2</sup> is a largest remnant of virtually intact forest in Thailand. The government has designated over the complex 17 protected areas, including national parks and wildlife sanctuaries. Protected area managers have, so far, made decisions without scientific supports. The Western Forest Complex Ecosystem Management Project (WEFCOM) was initiated in 1999 to assist the managers on scientific and cooperative supports. A main project activity is "rapid assessment of faunas" that focuses on wide ranging animals. The target species are such as elephant, guar, banteng, tiger, sambar, and tapir. Use of trail transects is a technique used to collect animal locations, tracks and signs, food and water sources, and signs of threats. Geographic information systems (GISs) are used for modeling of the distributions and habitat suitabilities. The results have shown that many large mammals intensively use the central zone designated as an UNESCO World Heritage site since 1991. Internal habitat fragmentation and degradation caused by people living inside the complex are reducing habitat suitability for native wide-ranging faunas. In conclusion, modeling of wide ranging animal distributions and habitat suitability is a cost-effective way for rapid assessment for ecosystem management of the area.

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## SMALL SCALE RESTORATION ECOLOGY IN TWO DIFFERENT REGIONS IN HAITI.

Conservative estimates of deforestation in Haiti indicate that only three to five percent of the original forest cover remains. International & governmental agencies have failed to stem the tide of deforestation. Concomitant efforts to reforest large tracts of land have also failed. Deforestation continues unabated even in national parks and biospheres. Using local collaborators, we have attempted to reforest small tracts of land in Haiti. Our three objectives were: 1) To provide economic and moral incentives to stop deforestation in these plots 2) To stop erosion 3) To increase forest cover and provide habitats for native fauna and flora. Our first experiment was conducted in Fermathe, Haiti on 3 hectares of land. The second experiment was conducted in La Serre, Haiti on 27 hectares of land. In Fermathe, we found that combining local economic incentives with small-scale reforestation efforts yielded an area with over 300 species. In La Serre, after five years we have seen a moderate increase in species diversity with a dramatic increase in forest cover. We describe the challenges that we faced in working with local communities and propose ways by which our methods can be used to create small sanctuaries of diversity throughout the island.

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## IDENTIFYING RAINBOW AND LAHONTAN CUTTHROAT TROUT HYBRIDS: INCREASED RESOLUTION USING MICROSATELLITE LOCI.

The Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) is listed as threatened under the Endangered Species Act. Landscape and population level research suggest that this species survived in a desert environment by living in large interconnected stream and/or stream and lake systems with metapopulation dynamics. The 1995 Recovery Plan for Lahontan Cutthroat trout mandates re-establishment of interconnected systems. The McDermitt Creek system in the Northwestern Lahontan Basin DPS is the only stream system with potential for re-connection in the foreseeable future in this DPS. Parts of the McDermitt Creek system have populations of Lahontan cutthroat trout introgressed with Rainbow trout. Previous mitochondrial DNA analysis did not reveal hybridization in three streams (Sage, Line Canyon and Indian Creeks) targeted for re-connection. Three microsatellite loci (*sfo8*, *ots1*, *ots4*) with bimodal allele size distributions in pure rainbow and Lahontan cutthroat trout were used for a fine-scale analysis of hybridization in these creeks for this study. The Line Canyon Creek population is the only population of pure Lahontan cutthroat trout remaining in the McDermitt creek system. The results of this study strongly suggest that highly variable marker systems such as microsatellites should be used in hybridization studies and diagnostic markers should be used if possible.

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FINE SCALE POPULATION STRUCTURE AND CONSERVATION.

The combination of powerful genetic markers with improved statistical procedures provide new tools for investigating the biology of plants and animals, often with important implications for conservation. This synthesis will review developments in the field including: assignment tests, spatial autocorrelation and other methods that collectively aid the investigation of population relatedness, migration and dispersal. While providing unprecedented power, these genetic methods are most effective when combined with experimental ecological investigations. The integration of ecological and genetic methods will be illustrated by our study of habitat fragmentation in native Bush Rats. Using microsatellites we have assessed genetic patterns within and among replicate remnant and 'control' populations within an artificial forest system. At a scale of 10 x 15 km, significant population differentiation has been detected. Unexpectedly, the patterns of population relatedness, and therefore likely connectivity, for both remnants and controls is more complex than predicted by spatial distribution. Along 1 km transects, significant genetic structure has been detected by spatial autocorrelation, indicating local restriction of dispersal. Assignment tests show there is no sex biased dispersal. We are now combining patch removal experiments with genetic analysis to quantify rates and patterns of Bush Rat dispersal in the fragmented landscape.

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CONSERVATION GENETICS OF THE EASTERN MASSASAUGA RATTLESNAKE (*SISTRURUS C. CATENATUS*).

The eastern massasauga rattlesnake (*Sistrurus c. catenatus*), currently exists as a series of declining isolated populations throughout eastern and central North America, and has recently been classified as threatened in Canada, and endangered in the United States. Recent analysis using microsatellite DNA loci showed that populations were highly differentiated from each other and exhibited high levels of variation. Here we use a different DNA marker (mitochondrial DNA sequence variation) to assess whether populations of this sub-species form sets of phylogenetically distinct clusters which may be of special conservation interest, and to provide an additional assessment of levels of genetic variation within single populations. We sequenced a 550 base pair fragment of the mitochondrial control region III for 61 individuals from populations from Wisconsin to Ontario. Among these individuals, only 7 haplotypes were found, and there was no significant phylogeographic structuring among populations based on mtDNA variation. From a conservation perspective, these results provide no evidence for phylogenetically distinct lineages among North American populations of eastern massasauga rattlesnakes. The low levels of variation observed in mtDNA compared to microsatellite DNA could be the result of differences in the roles of selection *versus* drift in moulding variation in each type of marker.

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ASSESSMENT OF THE IMPACT OF URBANIZATION AND EXOTIC ANTS ON NATIVE ANT DIVERSITY IN ORANGE COUNTY, CALIFORNIA.

Southern California is a region characterized by high species diversity and endemism. Urbanization and exotic species invasions threaten many native species. Habitat conservation planning has recently created natural land reserves with the goal of maintaining ecosystem function and biodiversity. In 1998, *Solenopsis invicta*, the Red Imported Fire ant, was detected in Orange County and has consequently become a potential threat to the natural diversity of these new reserves. Monitoring the distribution of *S. invicta* began shortly after its discovery and was focussed in urban areas. *S. invicta* has since been detected at approximately 10,000 localities in the urban matrix. The USGS implemented ant sampling in winter 1999/2000 within Orange County reserve lands to determine if *S. invicta* has spread to natural communities and to inventory resident ant communities. To date, over 19,000 ants have been captured within the reserves. The exotic Argentine ant, *Linepithema humile*, is widespread in fragmented sites and along the urban or agricultural edge of these reserves. *Solenopsis invicta* was not found in any of the sampled natural areas. Continued sampling is essential to monitor the invasion patterns of *L. humile*, potential future spread of *S. invicta*, and their impacts on native ant fauna.

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#### FOREST - FISHERIES INTERACTIONS ON THE WEST COAST OF CANADA: A PALEOECOLOGICAL PERSPECTIVE.

Parks Canada has a mandate to maintain the ecological integrity of terrestrial and marine ecosystems in representative regions within Canada and its national waters. In order to understand the ecological integrity of any given ecosystem it is essential to understand the natural range of variability in which the system exists as well as the impact people have had on it. This study is a multiproxy investigation that uses palaeoecological methods to reconstruct environmental conditions for the last ~300 years in three lakes and their watersheds on the west coast of Vancouver Island. Pollen, sediment, and stable isotope analyses of <sup>210</sup>Pb dated sediments from Hobiton, Cheewhat, and Tsutsiat Lakes in Pacific Rim National Park Reserve of Canada reveal changes in vegetation, sedimentation, and nutrient levels over time. These data suggest that 20<sup>th</sup> century logging and fishing practices have had impacts on the temperate rain forests and pacific salmon abundance of coastal British Columbia. Results of this study also have implications to management of the national park when considering ecosystem restoration, lake fertilisation, logging practices along the edge of the park, and fishing practices in the waters protected by the park.

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#### PREDICTING THE LONG-TERM EFFECTS OF DISTURBANCE ON SMALL MAMMALS.

Effective conservation and management is dependent upon knowing enough about a species or population and its ecosystem to make informed decisions for its long-term survival. Population Viability Analysis (PVA) can help to identify populations or species at risk of extinction and target management towards them. Here we have used historical data and knowledge of the threats facing three small mammal populations to predict their likely abundance in a disturbed forest. Regression analysis indicates a good fit between the model's predictions and the observed trends. The models are best for *Antechinus agilis* and *Rattus fuscipes*. The current management regime for the forest involves commercial logging on a 20 year cycle and prescribed burning. PVA predicts that of the species studied, *A. swainsonii* is at the greatest risk of extinction. To improve the overall prognosis, research and management should be targeted towards reducing the risk for this species. Sensitivity analysis identifies migration, mortality and fertility as the three main areas that need to be targeted to maximize the survival of these species.

PEREIRA, SÉRGIO LUIZ, and Anita Wajntal. Department of Biology, University of São Paulo, São Paulo Brazil. Rua do Matao 277, sala 215, 05508-900, Brazil.

#### CAPTIVE BREEDING AND REINTRODUCTION OF CRACIDAE IN BRAZIL: GENETIC STUDIES.

Cracidae birds are important key species in the dynamics of forest regeneration since they are seed dispersers. Successful captive breeding has been reported but the reintroduction to the wild has been questioned to be of limited value in species recovery, as it may be associated to increased costs and risks. We used DNA fingerprinting to analyze the genetic variability of captive stocks of three species of Cracidae (*Penelope obscura*, *P. superciliaris* and *Crax blumenbachii*) used in two different reintroduction programs in Brazil. In these programs captive born birds were released to the wild. However, these birds are the outcome of a few couples kept in captivity. DNA fingerprints showed that the wild established populations are related to the released birds. Despite the efforts to avoid first degree relationships in the captive breeding couples, after 9 generations there was at least 12% decrease in heterozygosity and

chicks from different couples had similarity indexes expected for first degree relatives. Considering that in both cases the original populations are locally extinct, we suggest that these newly established wild populations should be further managed by reintroducing some captive-bred birds, per generation, with a different genetic constitution, in order to increase their genetic variability.

PERERA, ANTONIO. Centro Nacional de Areas Protegidas. Calle 18A #4114, Playa, Ciudad de la Habana, Cuba. STATE OF THE CUBA'S PROTECTED AREAS AT THE BEGINNING OF THE 21<sup>ST</sup> CENTURY: CHALLENGES AND PERSPECTIVES.

Cuba has a National System of Protected Areas integrated by 81 areas of national significance and 155 areas of local significance that were selected by using specific criteria. A new Law for Environment enacted in 1997 officially established the System as well as the objectives, basic concepts and regulations. A specific legislation, the Decree-Law 201 of 1999 of The National System of Protected Areas develops the conceptual framework and system management tools that are applied. New institutional arrangements took place in the last 5 years, with the Ministry of Science Technology and Environment and the Ministry of Agriculture as the main actors. Only 40 areas have personnel and infrastructure, 6 of them were designated by UNESCO as biosphere reserves and one was listed as World Heritage Site. A GEF project for the system strengthening is underway from the beginning of 2001, with the participation of WWF, UNF and others. The Strategic System Plan identifies the main threats and weaknesses of the system as well as the strategies to eradicate them. We describe the system development approach based on bioregional planning and public participation, the current information system and data management mechanisms used.

PFEIFFER, JEANINE, Yeremias Uril, Yohannes Jehabu, and Andreas Ambe. University of California at Davis, Graduate Group in Ecology, One Shields Avenue, Davis, CA 95616, USA (JP), ECO-SEA, PO Drawer 1710, Davis, CA 95617, USA (JP, YU), and Masyarakat Tado, Kotak Pos 3, Labuan Bajo 86554, NTT, Indonesia (YU, YJ, AA). TRACKING THE SYNERGY BETWEEN CULTURAL AND BIOLOGICAL DIVERSITY: COMMUNITY ECOLOGY IN EASTERN INDONESIA.

To demonstrate the intrinsic, synergistic relationship between cultural and biological diversity, this research conceptually and graphically maps the cultural and ecological landscapes of an indigenous agrarian community in order to visualize the interconnectedness of the components. Intergenerational changes in cultural practices and the local ecology are delineated as a basis for identifying endangered traditions and natural resources, determining the forces which threaten them, and developing strategies to conserve both biological and cultural diversity. To prove that the relationship between cultural identity and natural resources actively contributes to conserving or eroding biological diversity, the research pioneers a multidimensional study of qualitative and quantitative shifts in native plant knowledge, use, harvesting, distribution and abundance. Qualitative inventories of ethnoecological traditions are accompanied by quantitative evaluations of ethnobotanical use values (EUVs) and plant cultural significance scores (PCSSs) for native plant taxa. Models of harvesting regimes are contrasted with natural and assisted rates of plant regeneration and reproduction in order to appraise the sustainability of current extraction and *in situ* and *ex situ* conservation management practices. The importance of involving indigenous community members in theoretical and empirical investigations of the forces impulsing cultural and ecological disintegration in their ancestral communities are highlighted throughout the presentation.

PILGRIM, JOHN. Center for Applied Biodiversity Science, Conservation International, 1919 M Street, NW, Suite 600, Washington, DC 20036, USA.

'WARMSPOTS' AND 'MAJOR TROPICAL WILDERNESS AREAS': ADDING TO THE BIODIVERSITY MAP.

Approximately 44% of the world's vascular plant species and 35% of terrestrial vertebrates are confined to 25 'hotspots'. The original hotspots analysis noted that several other regions with exceptional endemism fall short of thresholds for hotspot status. Three of these are the 'major tropical wilderness areas' of the Amazon, Congo and Melanesia, which together hold more than 49,000 (16% of global total) plant species and 1,950 (7%) terrestrial vertebrate species as endemics. Further analysis shows that an additional ten distinct highly threatened regions, or 'warmspots', might each harbor nearly 0.5% of global plants as endemics. After these areas, there appear to be no biogeographic regions holding many more than 500 endemic plants. The ten warmspots are the pine-oak woodlands of southern North America, the Ethiopian highlands, the Horn of Africa, the Albertine Rift, western Angola, Maputaland-Pondoland, the mountains of Central Asia, Taiwan, the mountains of south-east China, and the Queensland Wet Tropics. Conservation of these areas could protect the entire distributions of an additional 10,000 (3.3% of global total) vascular plant species and over 600 (2.2%) terrestrial vertebrate species. While the hotspots hold greater biodiversity and endemism, a global conservation strategy should not ignore these important secondary areas.

PLAVSIC, MILA J., and Jesús Almonte. U.S. Fish and Wildlife Service, 4401 N. Fairfax Drive, MS 634, Arlington, VA 22207, USA (MJP), Progressio, A.P. 22036, Av. Maximo Gomez, Santo Domingo, Dominican Republic (JA).  
**MAPPING AVIFAUNAL DIVERSITY IN DATA-POOR COUNTRIES: HOTSPOTS FOR BIRD SPECIES IN THE DOMINICAN REPUBLIC.**

In biodiversity-rich but data-poor countries, it is difficult to map biodiversity hotspots and aid in prioritizing conservation actions. As birds are often relatively better studied than other taxonomic groups, we sought to use readily available data on avian biogeography to create a coarse-filter map of avifaunal hotspots in the Dominican Republic. We chose 39 bird species, representing all endemic birds on the island of Hispaniola plus a few rare and breeding residents and high-priority non-breeding residents. We first digitized range maps for each species and then assigned vegetation types (from a remotely sensed vegetation map) important to each species, based on a survey of experts. After creating composite maps for each species that contained only important vegetation types within each species' range we added the 39 individual composite maps together to identify hotspots. Protected areas boundaries were added to show where hotspots are currently unprotected and which protected areas are especially important for avian conservation. The Dominican government and NGOs are now using the resulting map to increase biodiversity protection on the island of Hispaniola. Using coarse data that are available in many countries, we have elucidated a methodology that can be easily replicated in other areas.

POLHEMUS, DAN A., Ronald A. Englund, and Steven D. Jordan. Dept. of Entomology, MRC 105, Smithsonian Institution, Washington, DC 20560 (DAP), Hawai'i Biological Survey, Bishop Museum, 1525 Bernice St., Honolulu, HI 96817 (RAE), Dept. of Ecology and Evolutionary Biology, U-43, University of Connecticut, Storrs, CT 06269, USA(SDJ).

**HAWAII AND THE MARQUESAS: CONTRASTING LESSONS IN THE CONSERVATION OF PACIFIC FRESHWATER BIOTAS.**

Hawai'i and the Marquesas are remote hotspot archipelagos lying in the Eastern Pacific Ocean. Due to their locations, both groups support similarly disharmonic freshwater biotas, with fish assemblages consisting of diadromous gobioids, and aquatic insect assemblages dominated by Diptera, coenagrionid Zygoptera, and certain aquatic Heteroptera. The two island chains have contrasting histories of environmental perturbation: the Marquesas are the only Pacific high islands still free from introduced freshwater fishes, while Hawai'i now harbors many, with biological impacts from inconspicuous poeciliids having been greater than those from sport fishes; the Marquesas were never subject to large scale sugarcane or pineapple plantation agriculture, which greatly altered the Hawaiian landscape; and the current population of the Marquesas is approximately 6000 people, compared to Hawai'i's 1.1 million. Conservation strategies for Hawai'i's freshwater biota emphasize mitigation of introduced species impacts, modification of agricultural diversions, translocation of endangered populations, and control of feral ungulates. In the Marquesas, conservation strategies are not yet in place, but should concentrate on prevention of initial introduction of alien fishes and other aquatic species via public education, minimization of further watershed degradation by feral ungulates, and assessment of possible insecticide impacts from past programs for control of endemic blackflies.

Porter, Warren, and LINDA FARLEY. University of Wisconsin (WP), American Bird Conservancy, 1250 24<sup>th</sup> Street NW Suite 400, Washington, DC 20037, USA.

**SCIENCE MEETS POLICY IN BIRD CONSERVATION.**

We present an application of a new, state-of-the-art bird energetics model, on a landscape scale. The model utilizes macroclimate data, bird morphology, and key physiological properties to calculate food and water requirements, metabolic and water loss rates, and respiration airflow requirements for any species of bird, in any climate, on a spatial scale. Measurements are made at one-hour intervals. This model is appropriate for quantitative estimation of exposure by respiration to any airborne chemical or pathogen. We use this model to determine the exposure of two species of birds, one federally listed as endangered, to the organophosphate pesticide, fenthion. Fenthion is sprayed for mosquito control in Florida and is an example of a pesticide that can affect migrating shorebirds at the population level. Predictions based on this model may explain the recent killing of seventeen species of birds in Florida by fenthion, when it was used according to label instructions. Our results were presented to the U.S. Environmental Protection Agency (EPA) in an effort to change existing policy by cancelling the legal use of fenthion.

POSSINGHAM, HUGH P. Centre for Conservation Biology, The University of Queensland, St Lucia QLD 4072, Australia.

**OPTIMAL RESERVE SYSTEM DESIGN IN AN UNCERTAIN AND DYNAMIC WORLD.**

Optimal reserve selection theory has concentrated on choosing sites where the landscape and species distributions are assumed to be static. I formulate the problem of selecting sites for conservation in a dynamic uncertain world. Uncertain events are included in the problem by allowing sites to be lost, and become available for acquisition, randomly. Stochastic dynamic programming is used to determine whether or not to buy a particular reserve at a particular time given the current state of the reserve system. The concept and method is illustrated with a small data set on bird species living in patches of remnant mallee and woodland in southern Australia. The results are contrasted with those from static reserve selection theory. Whether a site should be selected depends not just on its complementarity to other sites but also on how replaceable the site is, and its chance of being destroyed. Some of our results are counter-intuitive – for example it may not be optimal to immediately acquire sites that are in the minimum set.

Powell, George, SUZANNE PALMINTERI, Achille Raselimanana, Nanie Ratsifandrihamanana, and Mark Fenn. World Wildlife Fund-US, 1250 24<sup>th</sup> St., NW, Washington, DC 20037, USA (GP, SP), Représentacion WWF, Madagascar, B.P. 738, Antananarivo 101, Madagascar (AR, NR, MF).

#### DEVELOPING CONSERVATION PRIORITIES FOR MADAGASCAR'S SPINY FOREST ECOLOGICAL REGION.

We developed a set of conservation priority areas designed to fully represent biodiversity in the spiny forest of southern Madagascar. This analysis expanded upon previous prioritization exercises by incorporating systematic analyses of beta diversity and habitat representation and minimizing conflicts with human activities. To capture the variation in vegetation types along physical and climatic gradients, five sub-ecoregions were determined by combining the best available physical data with expert input. Ecoregion-level maps of biological importance, based on expert consensus and occurrence of unique biological elements, and intactness, based on neighborhood analyses of habitat cover, were combined in a GIS. To evaluate threats and opportunities for conservation action, we modeled distribution of potential human impacts on biodiversity, based on infrastructure, access, towns, demographics, soil productivity, etc., assigned impact values to each factor, and combined them into a "conservation opportunity" map. The biodiversity value, intactness, and conservation opportunity values were integrated into a single map of 22 conservation priority areas divided into 4 ranked categories. Priority areas from the top three categories were required to achieve the desired 15% minimum representation of each vegetation type in each sub-ecoregion. These areas will form the basis of a conservation landscape for the region.

POWERS, A. TRACEY, Susan M. Farabaugh, Nancy C. Harvey, and Barbara Schmelting . Zoological Society of San Diego, Hawaiian Endangered Bird Conservation Program, P.O. Box 39, Volcano, Hawai'i 96785 (ATP ,BS), Zoological Society of San Diego, Center for the Reproduction of Endangered Species, P.O. Box 120551, San Diego, CA 92112-0551, USA (SMF, NCH).

#### VIDEO MONITORING AND MANAGEMENT OF BREEDING BEHAVIOR IN CAPTIVE 'ALALA.

The 'Alala (*Corvus hawaiiensis*) is an endangered corvid endemic to the island of Hawai'i. The Keauhou Bird Conservation Center (KBCC) and the Maui Bird Conservation Center (MBCC) manage the captive flock of 27 birds. In 2000, there were eight breeding pairs of 'Alala, three of which were newly paired. Time lapse videos of nest platforms of each pair were recorded for 3 hours each day, alternating daily 7-10am or 1-4pm. Tapes were reviewed daily to quantify two female behaviors: nest cup formation and percent in nest. Management of the breeding pairs was based in part on fluctuations in rates of these behaviors. Ad lib observations of intra-pair aggression or disturbance of the breeding females by the males were also noted, and males were removed from the nesting area when necessary. The behavior of the females during the 2000 breeding season fell into three general categories: 1) females exhibiting normal nesting behavior ; 2) females with new mates that showed potential for 2001; 3) females exhibiting poor nesting behavior. Videotape review enabled the staff at KBCC and MBCC to manage the captive population of 'Alala by minimizing mate disturbance at the nest and facilitating egg production.

PRATT, THANE K., Bethany L. Woodworth, and Richard J. Camp. USGS Pacific Island Ecosystems Research Center, P. O. Box 44, Hawai'i National Park, HI 96718, USA.

#### IS THE HAWAIIAN AVIFAUNA SUSTAINABLE?

Prior to human settlement, the Hawaiian Islands supported one of the largest insular avifaunas, with 124+ species or subspecies known so far and other fossil species being discovered. Tragically, 64+ species disappeared as a direct or indirect result of human settlement, which began about 600 AD. Evolution in insular environments led to development of adaptations predisposing the birds to new sources of disease, predation, and competition. While only about 50% of the original avifauna has survived, individual species responses have varied greatly. Despite the depressing proportion

of endangered species (46%), the less-threatened species are generally abundant in suitable habitat, having to some degree either escaped or adapted to environmental changes. Conservation of Hawaiian birds must necessarily proceed on a broad front of responses, by strategically protecting and restoring suitable habitat, by minimizing or altogether removing threats, and through reintroductions of birds from captive sources.

PRAYURASIDDHI, THEERAPAT, Chatchawan Pistamkham, Anak Pattanavibool, and J. L. David Smith, Royal Forest Department, Paholyothin Rd., Bangkok, 10900, Thailand and Conservation Biology Program, University of Minnesota, St. Paul, MN 55108, USA.

#### THAILAND'S WESTERN FOREST COMPLEX ECOSYSTEM MANAGEMENT PROJECT.

The Western Forest Complex (WEFCOM) is the largest surviving forest tract in Thailand covering 18,730 sq. km; it is composed of 17 protected areas. Tiger, elephant, gaur, banteng, water buffalo and tapir are among 153 mammals and 490 birds recorded. Local land use practices in the sanctuaries and the 5 km buffer zone are a potential threat to the integrity of this ecosystem (e.g. shifting cultivation, agriculture encroachment, wild fires, infrastructure development, mining, illegal logging and poaching of wildlife). The purpose of this presentation is to report progress on an innovative approach to ecosystem management. The project's objective is to maintain the integrity and health of the WEFCOM through a multisectoral approach that emphasizes local participation. Major components of the project include: (1) integrated management through a series of forums that bring together local government, NGOs and local communities, (2) spatial database development that includes results from ecological and socio-economic surveys and monitoring efforts, (3) training of 1800 rangers at 153 ranger stations, and (4) a grant program for local people to develop alternatives to current land use practices. The major stumbling blocks are need for institutional change and lack of mid-level staff to supervise professional capacity building of rangers.

PRICE, DONALD, Cam Muir, Sheryl Moore, Dena Flesher, Dena Cutler, and Lisa Canale. University of Hawai'i at Hilo, Hilo, Hawaii, USA.

#### HYBRIDIZATION AND THE PHENOTYPIC AND GENETIC INTEGRITY OF TWO HAWAIIAN DROSOPHILA SPECIES.

The integrity of rare species can be threatened by hybridization with related species. *Drosophila heteroneura* and *D. silvestris* are rare endemic Hawaiian picture-winged flies from the Big Island that hybridize in nature and the laboratory and are now experiencing dramatically reduced population sizes. The morphological differences of the last known *D. heteroneura* population and several *D. silvestris* populations that are now sympatric (South Kona Forest Reserve: SKFR) and allopatric (Puu Makaala: PMAA) with *D. heteroneura* do not indicate a high degree of hybridization. *D. silvestris* males from SKFR out-compete PMAA males in mating with SKFR and PMAA females. In contrast, the *D. silvestris* males do not out-compete *D. heteroneura* males in mating with *D. silvestris* or *D. heteroneura* females. However, hybridization occurs easily among *D. silvestris* females and *D. heteroneura* males. The clustering and minimum spanning networks from DNA sequences of wild caught *D. silvestris* indicate that SKFR and PMAA populations show genetic isolation. Bifurcating phylogenies show the relatedness of the *D. silvestris*, *D. heteroneura* and putative wild and laboratory hybrid individuals. These results indicate that hybridization along with declines in population size and population isolation may increase the likelihood of *D. heteroneura* extinction.

PRICE, JONATHAN. Graduate Group in Geography, University of California, Davis, CA, 95616, USA.

#### INTRODUCTIONS, EXTINCTIONS, AND CHANGING SPECIES-AREA RELATIONSHIPS IN HAWAII.

Species-area relationships (SPAR's) can be distinguished into three major types: between samples or plots of varying size, between islands or isolates of varying size, and between evolutionary provinces (regions defined by high endemism) of varying size. Human perturbations have altered SPAR's through species introductions, local extirpations and global extinctions. The Hawaiian Archipelago is a good system in which to examine these changes because it is an evolutionary province with well-studied human impact. In order to determine changes in different types of SPAR's, distributional data was obtained for native and naturalized species at the scale of: 1). the archipelago as a whole, 2). individual islands, and 3). samples within islands. It appears that there has been a net increase in diversity at the scale of samples/plots, individual islands, and the province as a whole because species introductions outweigh extinctions and local extirpations. This multi-scale increase in diversity maintains some semblance of SPAR's within the province, despite global extinctions. Because both introductions and extinctions effectively lower endemism, self-contained evolutionary processes no longer define the province. The global impact may be that smaller provinces are being subsumed into larger provinces, constituting a new scale of endangered diversity.

PRIDE, R. ETHAN. Dept. of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544, USA.

## DOES CORTISOL PREDICT SHORT-TERM FITNESS IN *LEMUR CATT*?

Fecal corticosteroid measurements provide a noninvasive physiological indicator of stress in vertebrates. Conservation biologists increasingly use corticosteroids to assess the impact of natural and anthropogenic pressures on wild populations. Despite this wide use, it is not known if observed differences in corticosteroid levels actually predict differences in survival and reproductive success in wild populations, even though this demographic ‘bottom-line’ is a primary conservation concern. In this study, I evaluate fecal cortisol as a predictor of individual adult survival, mating success, and infant survival in a population of ring-tailed lemurs (*Lemur catta*) at Berenty Reserve, Madagascar. I compare cortisol to two other easily-obtained health measures, coat condition and nematode infestation, as fitness predictors. Results from two years of observation and 1200 fecal samples indicate that coat condition predicts all three fitness components, nematode infestation predicts only male mating success, and cortisol predicts fitness best when other environmental factors are taken into account. Corticosteroid levels in themselves provide limited insight into short-term demographic trajectories, but should be used with complementary indicators in determining conservation status.

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## TAKING CONSERVATION BIOLOGY ON THE ROAD: RESULTS FROM THE SPINNING TOWARD SOLUTIONS PROJECT.

Outreach and education are an essential component of conservation practice, and they provide a mechanism for building a foundation of public support that can be tapped when dealing with specific issues of concern. During Fall of 2000, the authors took this message on the road with a Society for Conservation Biology-sponsored project called Spinning toward Solutions. The project centered on a cross-country tandem bicycle ride, which reached 5,000 kids in 45 schools across 11 states during an 80-day expedition. Several important conclusions can be drawn from this sample of schools. Our report summarizes some of the observations and experiences gained during the expedition, while making some general conclusions that might benefit future education and outreach projects. Lessons include: (1) the importance of an exciting and unusual “hook” for drawing larger audiences, capturing student attention, and focusing media interest, (2) the benefits of collaborating with an existing network of schools involved in environmental education (in this case, the Global Learning and Observations to Benefit the Environment program), and (3) the importance of putting an enthusiastic conservation biologist into the classroom. These successes highlight the enormous potential of “event-based” activities in contributing to the Society’s goal for public education and outreach.

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## EVALUATING POPULATION VIABILITY IN *ERYNGIUM CUNEIFOLIUM*: DECIPHERING A DECADE OF DEMOGRAPHIC DATA.

We model demography of *Eryngium cuneifolium*, a Florida scrub endemic. Using 10 annual censuses (1990-1999) of 11 populations at Archbold Biological Station, we built 54 matrices representing different time-since-fire and evaluated twelve fecundity and seed bank scenarios. The stochastic simulation program DISTPROJ was used to obtain estimates of extinction probability under different regular fire intervals. The scenario with high seed bank survival (0.5) and low germination rates (0-0.4) was the best predictor of observed years of peak plant number (8) and aboveground disappearance (30-34). Time-since fire had major effects on demography. Survival of seedling cohorts recruiting shortly after fire was greater than for later cohorts. Finite rates of increase were  $> 1$  only during the first decade postfire, and decreased with time-since-fire. Elasticities for survival increased with time-since-fire, while other elasticities decreased. Our results indicated that frequent fires with return intervals of 15 years or less are necessary for *E. cuneifolium* persistence. Since rosemary scrub may burn less often, local extinctions and metapopulation dynamics may be the norm for this species. Other rosemary scrub specialists (e.g. *Hypericum cumulicola*) thrive with less frequent fires. Therefore, we suggest that variation in fire regimes will allow co-existence and hedge against local extinctions.

RAGONE, DIANE, Paul Matthew Cox, Joan M. Stevens, Patricia Ann Stewart, Rebekka Stone, Gaugau Tavana, and Paul Alan Cox. National Tropical Botanical Garden, 3530 Papalina Rd. Kalaheo, HI 96741 (DR, GT, PAC), Brigham Young University, Provo, Utah 84602 (PMC), Dept. Of Biological Sciences, California State University, Fullerton, California 92834 (JMS), West Dermatology, 200 North La Cumbre Road, Santa Barbara, CA 93110 (PAS), New York Botanical Garden, Bronx, NY 10458-5126, USA (RS).

## USING TRADITIONAL KNOWLEDGE TO CONSERVE BREADFRUIT DIVERSITY IN THE PACIFIC ISLANDS.

Breadfruit is an important staple crop throughout the Pacific but many cultivars are becoming rare or disappearing. An integrated approach to breadfruit conservation encompassing both *in situ* and *ex situ* strategies is needed. Several breadfruit germplasm collections have been established in the region since the 1960s. However, most have been neglected or abandoned because of the long-term commitment of land and labor required for their maintenance. An ethnobotanical study of local breadfruit names in Samoa can serve as a model for using traditional knowledge to identify those cultivars that require *ex situ* conservation and those that are being conserved *in situ*. We interviewed 354 Samoans in American and Western Samoa and recorded more than 40 cultivar names. Of these, two cultivars, ma'afala and puou, were known by 88% and 81% of the respondents, respectively, and four others were known by more than 50% of the respondents. All were widely grown in or around the villages. Close to 20 cultivars were known by only one person, each of whom was identified as an expert informant. Quantitative inventories of breadfruit trees in Samoa will determine the relative frequency of these rare cultivars and target them for *ex situ* conservation.

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## ESTIMATING EFFECTIVE NUMBER OF MALES: A NEW METHOD.

Mammalian mating systems are generally polygynous, with males controlling one or more females. The degree of polygyny changes the effective size of the population, with more polygynous species having a lower effective size,  $N_e$ . As  $N_e$  affects the future evolutionary potential of a population, its estimation is of importance to conservation biologists. We propose a new method to estimate the effective number of males contributing genetically to a population based on differences in maternal and paternal allele frequency distributions. Using an individual based model, we show that this method successfully differentiated between extreme mating systems: random mating and harem polygyny. Further, we investigated the dependence of the method on sample size and the number and kind of genetic loci used for analysis.

RANDRIARIMALALA ZO LALAINA. Box 14, Kennedy Hall Cornell University Ithaca NY14850; Conservation International, Madagascar Program. Box 5178, Antananarivo, Madagascar.

## CONSERVATION ISSUES OF THE LOWLAND RAIN FOREST IN MADAGASCAR; CASE STUDY OF ZAHAMENA NATIONAL PARK.

The biodiversity of Madagascar is one of the richest in the world, and most of its biological richness is found in the lowland forest in the southern and the eastern parts of the island. In Zahamena National Park, we found the rare species such as lemurs, *Allocebus Trichotis*, birds, *Eutriorchis asture*. Unfortunately human pressure such as slash and burn for agriculture, logging, and hunting has decreased the area of lowland rain forest. In addition the soil quality of lowland rain forest is good for cash crops such as coffee, vanilla, litchi. Most of the Malagasy, estimated at about 75 percent of the population are farmers, and their livelihood depends on the forest. Facing these problems, Conservation International with the help of national agencies such as National Association for Protected Area Management (ANGAP), International agencies such as USAID, implemented a biodiversity conservation and rural development program to improve income levels and living conditions for the local communities by providing alternatives to forest destruction.

RAO, MADHU, Alan Rabinowitz, and Saw Tun Khaing. Wildlife Conservation Society, International Programs, 185<sup>th</sup> Street and Southern Boulevard, Bronx, NY 10460, USA.

## BIODIVERSITY CONSERVATION IN MYANMAR: A REVIEW OF THE PROTECTED AREA SYSTEM.

With large areas of forest cover remaining, Myanmar represents a unique opportunity to conserve biodiversity within protected areas. Deforestation, unrestricted hunting, and destructive agricultural practices have resulted in significant wildlife declines and rapid loss of natural habitats. We analyzed the status of 20 out of the 31 officially gazetted protected areas within a framework that classified activities incompatible with protected area status into two broad categories (small vs. large-scale). Small-scale incompatibilities driven by economic necessity and lack of alternatives occurred more frequently than large-scale incompatibilities caused by larger economic interests. Extraction of non-timber forest products was reported in 85% of the protected areas and ranked highest among the 16 identified incompatibilities. Grazing, hunting, fuelwood extraction and permanent settlements occurred in more than 50% of the parks surveyed. 40% of the protected areas had some infrastructure for reserve management but insufficient on-site personnel to adequately perform management activities. Older protected areas were found to be more neglected than

recently established protected areas. Major recommendations include involving local communities in the management of protected areas and buffer zones, building technical capacity of protected area staff, implementing a comprehensive land-use and making amendments to existing wildlife laws to fulfil international treaty obligations.

RASMUSSEN, MARY C., and Michael P. Murray. Crater Lake National Park, P.O. Box 7, Crater Lake, OR 97604 (MCR) and Oregon Natural Heritage Program, 821 SE 14<sup>th</sup> Ave, Portland, OR, 97214 (MPM), USA.

#### MONITORING THE HEALTH OF ALPINE ECOSYSTEMS USING A VITAL SIGNS APPROACH.

National Parks have been established over time to preserve unimpaired, self-sustaining examples of natural ecosystems. Presented with the challenge to understand, restore, maintain and protect natural resources, progressive park managers have instituted ecological monitoring strategies to inform, guide, and evaluate ecosystem preservation efforts. Crater Lake National Park, Oregon, takes a “Vital Signs” approach to ecological monitoring. This monitoring approach has four goals: 1) identify trends in ecosystem health; 2) determine normal limits of variation; 3) provide early diagnosis of abnormal conditions; and 4) identify potential agents of abnormal change. Using monitoring data from the park’s isolated alpine ecosystems we examine the benefits of using a “Vital Signs” approach. For example, we discovered that a non-native fungus currently infects up to 20% of the park’s whitebark pine trees. Without management intervention, we predict a 46% decline in mature whitebark pine by 2050. The resultant loss of food supply (pine nuts) will have negative effects on nutcrackers, black bears, and red squirrels. Taking a “Vital Signs” approach to ecological monitoring allows our National Parks to be understood, restored, maintained, and protected so that current and future generations can enjoy their wonders, receive their inspiration, and reap the values of their unimpaired ecosystems.

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#### HURRICANE EFFECTS ON RECRUITMENT OF ISLAND PLANTS: THE GOOD, THE BAD, AND THE IRRELEVANT.

Recently, the effects of major hurricanes on plant recruitment have been studied, but little is known about the mechanisms responsible for the patterns observed, or whether effects vary between different species, hurricanes or local sites. I studied three woody plant species before and after two major hurricanes on San Salvador Island, Bahamas: Hurricane Lili (category 2) in October 1996 and the severe Hurricane Floyd (category 5) in September 1999. For *Pavonia bahamensis* (Malvaceae), Lili decimated its bird pollinators, severely limited fruit set, and precluded seedling recruitment. In contrast, bird populations were unaffected by Floyd, and *P. bahamensis* had a unique burst of successful seedling recruitment. For White Mangrove (*Laguncularia racemosa*: Combretaceae), seedling recruitment was rare after Lili but was unusually high after Floyd. However, at one local site all the seedlings died because fruits were dispersed beyond the mangrove zone, while survivorship was high at a second site. For *Bourreria succulenta* (Boraginaceae), flowering was dramatically prolific after Lili but not after Floyd, and fruit set failed because of poor pollination and severe flower/fruit predation. However, this fruit failure was possibly irrelevant because local seedling recruitment is very rare.

RAY, CHRIS. Biological Resources Research Center, Department of Biology, University of Nevada, Reno, NV 89557-0015, USA.

#### A SIMPLE MODEL FOR PROJECTING GROWTH IN CLASS-STRUCTURED POPULATIONS LINKED BY DISPERSAL.

Most metapopulation models require estimates of dispersal between local populations. Here I discuss a model that circumvents the difficulty of estimating dispersal. This model predicts the dynamics of a network of local populations, by extending an approach familiar to structured population models. Structured population models are based on class-structured demographic rates and (often) on any variation in those rates related to variation in class density. Similarly, this ‘structured network’ model is based on class-structured *local* demographic rates and any variation in those rates related to variation in *local and/or non-local* class density. In this model, dispersal is implicit in the relationships between *local* demographic rates and *non-local* density. For example, local recruitment may be related to adult density at the local scale, implying no adult dispersal, or it may be related to adult density at the network scale, implying high adult dispersal. Local ‘survival’ of a class may be related to non-local densities due to immigration or emigration. This model requires a set of synchronous demographic time series from different locations within the network. I discuss an application of this model to data from a network of cutthroat trout, including several challenges encountered during this exercise.

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#### A TEST FOR SAMPLING BIAS IN CONSERVATION PRIORITY-SETTING.

Attempts to identify areas with high levels of species richness and endemism have increased dramatically, as fragmentation of natural habitat mounts. These priority-setting exercises usually involve plotting the overlap of species ranges, as determined from locality records. Locality records for most species, however, are often dependent on collection or observation effort, and may thus be highly susceptible to sampling bias. We present here a linear test of sampling bias for geographical data, based on the expected distribution of observations within ecologically determined ranges. Our test provides confidence limits to the estimation of biodiversity priorities based on point records. We applied this test to a data set consisting of point localities of African birds. In many cases, areas of high priority, as determined by the locality data could not be statistically distinguished from better-sampled areas. Greater emphasis should be placed on the interpretation of conservation priorities established from locality data: these may have more to do with sampling efforts than with species richness. Conversely, this test can identify areas where more sampling is needed.

REDFORD, K.H., and John G. Robinson. International Conservation Programs, The Wildlife Conservation Society, 2300 Southern Blvd., Bronx, New York 10460, USA.

#### THE WILDLIFE CONSERVATION SOCIETY: MISSION AND STRATEGY.

The Wildlife Conservation Society is a non-governmental organization established as part of the New York Zoological Society over 100 years ago. It currently is involved in conservation projects in 53 countries involving the conservation of wildlife and wildlands. In this talk we present the new mission statement and set of conservation strategies and outline challenges facing implementation of the mission in varying ecological and political settings.

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#### HOW PRECAUTIONARY ARE WE? THE IMPACT OF UNCERTAINTY ON THREATENED SPECIES CLASSIFICATIONS.

Currently, a broad range of methods is used to classify species conservation status. Most methods rely on quantitative criteria for which there is often very little data, inducing poor confidence in the resulting classification of threat. The problem of dealing with uncertainty is a thorny issue for classification schemes. While bounding methods are useful tools for capturing the effects of uncertainty, they often result in vacuous outcomes upon which it is difficult to make decisions. As a partial remedy, the IUCN recommend a precautionary approach to uncertainty. But how precautionary is such an approach to uncertainty? What degree of precaution is necessary to produce a conservation status that is representative of the species? With the use of models to simulate a variety of data, we show the impact of uncertainty on threatened species classification protocols including those advocated by the IUCN, The Nature Conservancy, the Florida Game and Fresh Water Fish Commission and the California Department of Fish and Game. We compare the performance and sensitivity of each method to the quantity and type of data. While all classification schemes suffer under incomplete data, we offer one perspective on how to enhance our decision-making process in the face of uncertainty.

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#### OPERATOR ERROR IN EXTINCTION RISK ASSESSMENT METHODS.

Conservation managers use species' conservation status to make management decisions. It is assumed that the species conservation status is a reasonably accurate reflection of its vulnerability to extinction. Criteria in classification protocols such as trends in range size and abundance act as surrogates for extinction risk. Yet, outcomes of classification protocols have not been compared with a broad range of other quantitative modeling methods for estimating risk of extinction. Issues including age and stage structure, or density dependence may have implication for conservation status and are not typically considered in assessments. Methods for classifying conservation status of threatened species require assessors to decide on point estimates for criteria that are inherently uncertain, to the extent that different assessors may generate different classifications. In this study, protocols employed by the IUCN, The

Nature Conservancy, Florida Game and Fresh Water Fish Commission and the California Department of Fish and Game were examined. We compared impacts on relative ranks of a set of species using the classification protocols to various assessor interpretations based on the same data sets. We compared these with estimates projected from population models for the same species set to illustrate the level of variation among methods of estimating risk.

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#### ANTS: CHALLENGES FOR QUARANTINE, PREVENTION, AND CONTROL IN AN ERA OF GLOBALIZATION.

The Hawaiian archipelago was free of ants before human habitation. Consequently, the unique native fauna, having evolved in the absence of ants, is extremely susceptible to ant predation. Much of the lowland arthropod fauna has already been severely impacted by some of the 46 species of adventive ants in the islands. Efforts to prevent the incursion of more ant species and methods to control established species are being developed. New policies that specifically address the potential invasion of ants, primarily the red imported fire ant (*Solenopsis invicta*), have been implemented by the Hawai'i Department of Agriculture. Recent (1999) discovery of the little fire ant (*Wasmannia auropunctata*) near Hilo prompted ant distribution surveys by Big Island schools as part of an environmental education program developed through the University of Hawai'i and by State agencies. These surveys have resulted in the discovery of two additional ant species previously not recorded from Hawai'i. Hawai'i Department of Agriculture personnel have been conducting nursery inspections and researching and implementing treatments to eradicate infestations and prevent dispersal of the little fire ant. Current prevention, quarantine, containment, education, rapid response, and treatment practices are being reviewed and recommendations are being developed by an interagency Hawai'i Ant Group.

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#### CHANGES IN KELP FOREST FISH ASSEMBLAGES: ANOTHER CASCADING EFFECT OF KILLER WHALE PREDATION ON SEA OTTERS?

Sea otter populations in the Aleutian archipelago have declined by an order of magnitude during the past decade, resulting in subsequent increases in sea urchin populations and decreases in kelp forest densities. These changes are believed to have resulted from increased predation by killer whales on sea otters. Though changes in otter, urchin, and kelp populations have been clearly documented, no studies have yet addressed their subsequent effects on kelp forest fish assemblages. We examined temporal and spatial patterns in the abundance and diet of rock greenling, *Hexagrammos lagocephalus*, the dominant fish in these communities. In the summer of 1986, data were collected on catch per unit effort (CPUE) of trammel net sets at sites where sea otters were either abundant, or rare or absent. We repeated these methods at the same sites in the summer of 2000. CPUE was significantly lower at islands that have undergone dramatic sea otter declines but not at islands where otters have been historically absent or rare. These findings indicate that sea otter declines have led to substantial changes in kelp forest food webs. They further suggest that shifts in the behavior of apex predators may have cascading and indirect impacts on communities.

RENJIFO, LUIS MIGUEL. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Calle 37 # 8-40, Bogotá, Colombia

#### EFFECT OF NATURAL AND ANTHROPOGENIC LANDSCAPE MATRICES ON THE ABUNDANCE OF SUBANDEAN BIRD SPECIES.

The nature of the landscape matrix can control the capacity of forest organisms to move among forest patches. It could influence local abundance of forest organisms and persistence in fragmented landscapes. The influence of three contrasting matrices on the relative abundance of 113 bird species in a subandean region of Colombia was evaluated. Abundance of individual species in forest plots within a continuous forest matrix were compared with abundance in forest fragments embedded in pastures or exotic-tree plantations. 65.5% of the species showed significant differences in abundance among sites surrounded by different matrices. The most important explanatory factors of variation in abundance within fragments were: abundance within continuous forest, presence in the anthropogenic matrices, migratory strategy, and habitat association. Species with small geographic ranges, and terrestrial insectivores had low

tolerance to fragmentation. Responses were highly species-specific, largely independent of foraging strata, trophic group, and taxonomic affinities. Several lines of evidence indicate an increase of connectivity among forest remnants surrounded by exotic-tree plantations compared to pastures. These results suggest that structurally complex anthropogenic matrices have a potential as management tools for bird conservation as a complement to habitat protection and restoration.

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#### CONSERVATION OF THE SIBERIAN FLYING SQUIRREL IN A HABITAT PATCH NETWORK IN NORTHERN FINLAND.

Landscape ecology addresses the importance of habitat and landscape associations of the species in management and conservation actions. In heterogeneous environments it is crucial to determine the spatial structure of the habitat network, landscape connectivity, and other landscape specific characteristics that contribute to an ecologically operative demographic unit of a species. We studied landscape responses of the Siberian flying squirrel in remnant boreal forest patches in northern Finland. We divided the landscape into three functionally different landscape classes: breeding habitat patches, dispersal habitat, and hostile open areas. Spatial pattern of these landscape classes were measured from a satellite image and analysed in GIS in order to account for the actual occupancy pattern of the species in north Finnish boreal forest landscape. Our results suggest that it is not always sufficient to consider the area of habitat patches and interpatch distances only but attention should also be paid to other landscape characteristics such as topography, habitat patch quality, the location and scale of hostile habitats, and recent land use history. It is necessary in species conservation and management efforts in boreal forest landscapes to include species landscape responses and structure of the habitat patch network in concrete action planning in practise.

REYNOLDS, MICHELLE. USGS Pacific Island Ecosystems Research Center, Hawai'i National Park, HI 96718, USA.

#### POPULATION DYNAMICS AND CONSERVATION OF LAYSAN ISLANDS'S RESIDENT DUCKS.

Laysan Island, part of the Hawaiian Islands National Wildlife Refuge Complex, is the last refugia of the Laysan teal, *Anas laysanensis*. I analyzed their population dynamics using USFWS population monitoring data (1991-2001) and a mark and resight study (1998-2000). Two hundred and sixty-six total Laysan teal were marked by July 2000. The Lincoln-Petersen population estimates for 1998-2000 are 288 (95% CI 232-434), 322 (95% CI 290-354), and 459 (95% CI 391-537) respectively. Despite the last two years population increases, estimates of duckling mortality ranged from 70-90%. Juvenile mortality appears to be the most important limit to population growth, suggesting Laysan's capacity to support duckling broods is limited. Ecosystem restoration on Laysan and the establishment of additional wild populations on other islands are needed to reduce their high extinction risks.

RICHARDS, CARL, Lucinda Johnson, Jeff Schuldt, John Hutchens, and George Host. Minnesota Sea Grant College Program, University of Minnesota, 2305 East Fifth Street, Duluth, MN, 55812, USA (CR), Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN, 55811, USA (LJ, JS, JH, GH)

#### KEY LANDSCAPE FEATURES REGULATING AQUATIC COMMUNITY STRUCTURE IN MIDWESTERN WATERSHEDS.

We evaluated the strength of hierarchical relationships between landscape features and aquatic communities as mediated by reach-scale stream properties. Seventy-six watersheds of similar size were selected across two states (MN and MI) that represented existing variation in geologic and land use patterns. Macroinvertebrates, fish, physical habitat, and watershed characteristics were assessed in all watersheds. A two-step procedure using direct gradient analysis (redundancy analysis) was used to identify 1) important reach-scale attributes influencing biota within study watersheds, and 2) landscape attributes influencing important reach-scale factors. Strong linkages (>50 of total variation explained) were found between biota and reach-scale factors in both regions. We also found relatively strong linkages (32-58% of total variation explained) between reach and watershed factors. Our comparisons between regions reveal some similarity but considerable heterogeneity in the relative importance of individual factors due in part to differences in overall landscape structure of the regions. Some watershed features (e.g. stream density, soil erosion potential) were important to stream communities in both regions and others (e.g. land use) were important in only one region. Macroinvertebrates were more strongly influenced by watershed characteristics than were fish indicating they may have stronger hierarchical connections to the landscape.

RIDDLE, ANN E., Kristine L. Pilgrim, L. Scott Mills, Kevin S. McKelvey, and Leonard F. Ruggiero. Wildlife Biology Program, School of Forestry, The University of Montana, Missoula Mt 59812, USA (AER, KLP, LSM), Rocky Mountain Research Station, USDA Forest Service, 800 E. Beckwith, Missoula, Mt 59807, USA (KSM, LFR) IDENTIFICATION OF MUSTELIDS USING MITOCHONDRIAL DNA AND NON-INVASIVE SAMPLING.

One of the most fundamental issues in conservation biology is the determination of species distribution and richness. Many species, including forest carnivores, are elusive and secretive, making it difficult or impossible to make even basic conservation decisions on listing, delisting, or threat status. Non-invasive sampling of hairs left on rub pads can substantially increase our detection of such species. In an extension of a nationwide project using more than 6,000 hair snags across 12 states to identify lynx over two years, we developed protocols to detect other carnivores in addition to lynx. We describe protocols we developed for identifying mustelids from the hair samples using the cytochrome b region of mtDNA and three restriction enzymes (HinfI, Hae III, and MboI). We concentrated on identification protocols for fisher and wolverine because of their sensitive status and relatively unknown population sizes. In addition, we were able to develop protocols for marten, mink, skunk, and badger. We show patterns of species in the 12 states based on their presence or absence. Our protocol facilitates insights into elusive species using non-invasive sampling and sub-optimal samples such as hairs.

RIVERA, MALIA, Christopher Kelley, George Roderick, and E. Gordon Grau. Department of Environmental Science, Policy and Management, University of California, Berkeley, 201 Wellman Hall #3112, Berkeley, CA 94720-3112, USA (MR), Hawai'i Institute of Marine Biology and Hawai'i Undersea Research Laboratory, University of Hawai'i, 1000 Pope Rd, Honolulu, HI 96822, USA (CK) Department of Environmental Science, Policy & Management, University of California, Berkeley, 201 Wellman Hall #3112, Berkeley, CA 94720-3112, USA (GR), Hawai'i Institute of Marine Biology, University of Hawai'i P.O. Box 1346, Kāne'ohe, Hawai'i 96744, USA (EGG) DEFINING MANAGEMENT UNITS IN THE HAWAIIAN GROUPEE USING POPULATION GENETIC ANALYSES.

The endemic Hawaiian Grouper, *Epinephelus quernus*, is an economically valuable species to Hawai'i's bottomfishing industry. Decades of intense fishing has led to a substantial decline in abundance around the Main Hawaiian Islands. In these areas, estimates of the spawning potential ratio (SPR), a measure which reflects the relative proportion of reproductive females in a fishery compared to that of a pristine state, dropped to only 20% in 1996—a level at which is officially recognized as over-fished under federal standards. However, once considered a separate stock, managers now maintain that populations occurring around the main islands are actually homogenous with the entire archipelago, and when averaged with the North West Hawaiian Islands, SPRs remain at healthy levels around 50%. Using genetic markers, we examined population structure of *E. quernus* to assess whether the current management strategies in place are biologically appropriate. Preliminary microsatellite data show significant allele frequency differences between the Main Hawaiian Islands and the North West Hawaiian Islands, indicating that *E. quernus* is genetically subdivided across the archipelago. The possibility of genetic structuring suggests that current management plans may be in need of revision.

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SOCIAL DIMENSIONS OF RISK: TOWARD A POST-NORMAL MODEL FOR GENETICALLY ENGINEERED ORGANISMS.

Conservation biologists are becoming increasingly concerned over the introduction of genetically engineered organisms (GEOs) because of their potential to negatively impact habitat and species conservation efforts. Ecologists have been attempting to map the forces of ecological risk over the release of GEOs for the past two decades. These efforts—conceptualized almost entirely by technical risk assessment—have culminated in a biosafety manual and the Caregena Protocol, which regulates the trade of and encourages further scientific research on GEOs for signatories to the Convention on Biological Diversity. Meanwhile, the social sciences (notably economics, psychology, sociology, and anthropology) have been broadening the conceptual and methodological approaches to defining, assessing, and predicting risk. Today, the field of risk assessment is attempting to move toward a post-normal science—a science that attempts to integrate many different disciplines' conceptualizations and methodologies for risk analysis. Because GEOs are now being released worldwide, there is a significant imperative to develop an all-encompassing, post-normal approach to mitigate the competition between the different academic paradigms and move forward with the business of applied risk assessment. This paper outlines the different social science paradigms of risk assessment and concludes with a post-normal model for assessing the environmental risks of GEOs.

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CONNECTING SHADE COFFEE ISOLATES TO FOREST RESERVES: THE LAST BEST HOPE FOR CONSERVING ARMY ANTS AND UNDERSTORY INSECTIVOROUS BIRDS IN WESTERN PANAMA.

Recent studies have concluded that understory insectivorous birds are highly vulnerable to forest destruction and/or fragmentation. We studied two species of Neotropical army ant and attendant birds in premontane forest, shade coffee plantations both adjacent to and isolated from forest and isolated sun coffee plantations. All habitats except sun coffee supported both species of army ant and a diverse assemblage of ant-following birds. During 411 swarming occasions studied between February and July (1996 and 1997), we detected 126 bird species of 28 families foraging above the ants. Only two species of professional ant-following birds, the Ruddy Woodcreeper and the Gray-headed Tanager were observed at both species of ant. High numbers of opportunistic resident and migrant birds contributed to the fact that the highest diversity of species was detected in adjacent shade coffee. Several species of forest resident birds that correspond with a particular foraging guild, such as understory bark insectivores, were never detected at swarms in isolated coffee plantations. Other species were detected only at swarms in forest. Shade coffee plantations provide additional habitat for numerous species of ant-following birds. However, there is a limit to the conservation value of isolated coffee plantations for many resident and migrant birds.

ROBERTS, GUINNEVERE. Department of Zoology, University of Hawai'i, Honolulu HI 96822, USA.  
INTERSPECIFIC COMPETITION BETWEEN INTRODUCED HONEYBEES AND NATIVE BEE SPECIES.

Introduced species can affect native ecosystems by displacing, preying upon or out-competing native species. Although introduced species are often held responsible for the decline of native species, there is often very little experimental evidence to support such claims. I used experimental manipulations of introduced honeybee (*Apis mellifera*) populations in Australia to demonstrate that this invader does in fact have a significantly negative effect on populations of native bee species. An ANOVA analysis of my data shows that my manipulation of honeybee populations had a significant effect on native bee populations ( $F_{2,20} = 4.59$ ;  $p = .016$ ); native bee populations increased significantly when honeybee populations were reduced, and decreased when honeybee populations were augmented. Further evidence suggests that the mechanism for this change is exploitative competition for shared food resources. My research supports the idea that introduced honeybee populations pose a serious threat to native pollinator species, but that the creation of refuges from which honeybees are excluded may help mitigate this threat.

ROBERTSON, CORY T., and Mart R. Gross. University of Toronto, Department of Zoology, 25 Harbord St., Toronto ON M5S 3G5 Canada.

RECOVERING ANCIENT FISH: DEMOGRAPHIC ANALYSES OF STURGEON.

Sturgeons are an ancient fish lineage. Most species are now endangered, vulnerable or threatened, and an incomplete understanding of their biology and demography has hindered conservation efforts. Here we report on demographic analyses that tackle the conservation challenges arising from the sturgeon's long lifespan, delayed maturity, and intermittent spawning. Matrix projection models and elasticity analyses for three sturgeon species reveal a characteristic sturgeon 'elasticity profile'. This profile includes equally high survivorship elasticities across the young-of-the-year (YOY) and juvenile age classes, rapidly declining elasticities with each year after maturity, and negligible fecundity elasticities. Improvements to survivorship are restricted to less than 20% for all juvenile and adult years, and population growth rate (?) is similarly restricted. By contrast, improvement to YOY survivorship is virtually unlimited, and ? is most responsive to this age class. Localization of the highest potential for population growth within the YOY class has important ramifications for species recovery. Hatcheries, harvest regulations, and habitat restoration programs are likely to achieve little population-level response if they do not target YOY survivorship. [Collaborators: Joe Repka, Toronto; David Secor, Maryland; Webb Van Winkle, Tennessee.]

ROBICHAUX, ROBERT, Ane Bakutis, Steven Bergfeld, Kealii Bio, Marie Brueggemann, Joan Canfield, Elizabeth Friar, James Jacobi, Patrice Moriyasu, Lyman Perry, Tanya Rubenstein, Timothy Tunison, and Frederick Warshauer. Hawaiian Silversword Foundation, P.O. Box 1097, Volcano, HI 96785, USA (RR, JC), Resources Management, Hawai'i Volcanoes National Park, P.O. Box 52, Hawai'i National Park, HI 96718, USA (AB, TR, TT), Division of Forestry & Wildlife, Department of Land & Natural Resources, State of Hawai'i, P.O. Box 4849, Hilo, HI 96720, USA (SB, LP), Kilauea Field Station, Pacific Island Ecosystems Research Center, U.S. Geological Survey - Biological Resources Division, P.O. Box 44, Hawai'i National Park, HI 96718, USA (KB, JJ, FW), Pacific Islands Ecoregion,

U.S. Fish & Wildlife Service, 300 Ala Moana Blvd., Honolulu, HI 96850, USA (MB), Rancho Santa Ana Botanic Garden, 1500 N. College Ave., Claremont, CA 91711, USA (EF), Volcano Rare Plant Facility, Center for Conservation Research & Training, University of Hawai'i, 1115 W. Kawai'ani St., Hilo, HI 96720, USA (PM).  
**REINTRODUCTION OF THE ENDANGERED MAUNA LOA SILVERSWORD, *ARGYROXIPHUM KAUENSE* (ASTERACEAE).**

The endangered Mauna Loa silversword has experienced a severe decline in distribution and abundance in historical times primarily because of the impacts of alien ungulates. Though formerly common in open mesic and wet ecosystems between 1,500 and 2,700 m elevation on Mauna Loa and Hualalai volcanoes on the Island of Hawai'i, the Mauna Loa silversword is now limited to three small remnant natural populations totaling fewer than 1,000 plants. We have recently initiated a large-scale reintroduction program for this species. As part of the program, we have implemented a managed-breeding strategy involving hand-pollination of plants that flower either in cultivation at the Volcano Rare Plant Facility or in the field. The strategy has enabled us to use many founders from the source populations, and to control their representation in the reintroduced populations. In 2000, we outplanted 5,500 seedlings into multiple protected sites on state and federal lands. Survivorship has been high, exceeding 90% at some sites. In 2001, we will outplant more than 6,500 additional seedlings. The longer-term goal of our public/private partnership is to reintroduce a total of 20,000-25,000 plants into protected sites across the historical range, and to restore key interspecific interactions linking silverswords to other ecosystem elements.

ROBINSON, TARA R., and W. Douglas Robinson. Auburn University, Dept. of Biological Sciences, 331 Funchess Hall, Auburn, AL 36849, USA.

**EL NIÑO-SOUTHERN OSCILLATION AFFECTS SURVIVORSHIP OF A PANAMANIAN FOREST BIRD: IMPLICATIONS FOR CONSERVATION.**

Terrestrial insectivorous birds are sensitive to forest fragmentation. Species in this guild depend on leaf litter insects as their food source. In turn, leaf litter insect abundance is tightly correlated with litter moisture levels. We documented the effects of the 1997-98 El Niño Southern Oscillation (ENSO) on the abundance of leaf litter insects and the survivorship of Song Wrens (*Cyphorhinus phaeocephalus*), a terrestrial insectivorous species, in central Panama. During the three years (1994-1996) prior to the 1997-98 ENSO, Song Wren survivorship ranged from 62 to 82% (all ages and sexes combined). Survivorship fell to 52% during 1997. Birds less than one year of age had the lowest survivorship (35%; females = 16%; males = 60%). Mean number of leaf litter insects per kilogram of leaf litter was 11.8 during the last month of the ENSO (April 1998); abundance nearly tripled shortly after the rains began in May. Because forest fragments tend to dry out faster than intact forest, terrestrial insectivores in forest isolates may suffer very high mortality during ENSO events. If climate models predicting increased ENSO frequency are accurate, terrestrial insectivores may be more susceptible to local extinction than previously appreciated because of microclimatic changes induced by global climate cycles.

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**CLIMATE CHANGE AND BIRD EXTINCTIONS ON A NEOTROPICAL ISLAND.**

Barro Colorado Island (BCI), Panama, is a 1600-ha hilltop isolated during construction of the Panama Canal. Since the first ornithological investigations in 1923, 35% of the avifauna has disappeared despite the continued existence of populations of all species in nearby mainland forests. We analyzed the ecological characteristics of all species lost from BCI and found that most species lost occupied narrow ranges within the wettest forests in central Panama. We compared the bird community composition of BCI through time with the species composition in each of 12 forested areas on the mainland. Immediately after isolation, the BCI community was most similar to the wet forest communities. Now, however, the community most closely resembles a dry forest bird community. A century-long drying trend has been documented in the region, which appears to be related to a global climate cycle rather than a result of deforestation or other local processes. We hypothesize that drying of the island has reduced availability of resources that wet forest species require, leading to their local extinction. Efforts to conserve tropical diversity in isolated reserves like BCI may be impeded when those reserves are exposed to global climatic changes that alter the microclimatic profile of the reserves.

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## THE CONSERVATION VALUE OF A UNIQUE LIZARD MONITORING PROGRAM IN THE MARIANA ISLANDS.

Monitoring programs often attempt to sample many places and species using low-grade relative population measures. We chose to census (count all individuals) of lizards in a limited sample of common habitats in the Mariana Islands. These censuses produced high-validity habitat-specific estimates of absolute population densities and biomasses. In addition to providing “true” density estimates illustrating the inaccuracy of prevalent relative population estimation techniques, this approach yielded ecological insights. We discovered previously unknown populations (e.g., *Nactus pelagicus* rediscovered after a 50 year hiatus from Guam). Our absolute population density estimates led to a better and more quantitative understanding of rarity in several species (e.g., two *Perochirus ateles* individuals known from Rota). We discovered that some nominally rare species were numerous, which moderated inappropriate regulatory zeal in limiting scientific collecting. Habitat-specific data revealed some mysteries (*Hemidactylus frenatus* is common in forested areas of Guam but essentially absent from comparable habitats on Rota and Saipan), and indicated that apparent competition between *Emoia caeruleocauda* and *Carlia fusca* was more likely due to mutually-exclusive habitat preferences. Population estimates provided quantification of the importance of introduced prey species (70% of lizard biomass on Guam) in sustaining high densities of Brown Treesnakes (*Boiga irregularis*).

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## LEGAL AND ILLEGAL WILDLIFE TRADE FROM SOUTH AMERICA TO THE UNITED STATES.

After habitat conversion and exotic species introductions, wildlife trade is believed to be the next most important threat to biodiversity. The US, in turn, is the world’s largest market for wildlife products, and South America one of its main suppliers. We examined 34,622 wildlife shipments (total value US\$122 million) entering the US from South America between October 1993 and May 2000. This is the first analysis of its kind at this geographical scale covering such taxonomic diversity. We explored the effect that socioeconomic and ecological variables in the US and exporting countries had on the volume of wildlife trade generated. Our purpose was to evaluate the role of supply *versus* demand in driving the trade in wildlife products. One of our main results is that the number of illegal shipments is significantly correlated with the number of endangered species in the exporting country, suggesting that the demand for rare species may be a critical factor driving the process. Legal and illegal trade are also correlated, suggesting that legal operations may provide a front for illegal wildlife traffic. Mitigating the impact of wildlife trade requires actions at all stages of the supply-demand continuum.

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## CONSERVATION OF EVOLUTIONARY POTENTIAL IN CAPTIVE POPULATIONS: AN EXPERIMENTAL STUDY.

Preserving a population’s ability to respond to natural selection is highly desirable when eventual reintroduction is one of the goals of a captive breeding program. While current conservation breeding strategies assume inevitable decline in evolutionary potential and aim to slow this loss, either increases or decreases are theoretically possible, depending on assumptions made about initial conditions. Experimental evidence to date remains indirect or equivocal; this study is the first designed specifically to test whether breeding to preserve gene diversity also preserves additive genetic variance ( $V_a$ ). Up to 64 populations ( $N = 10$ ) of wild-caught milkweed bugs (*Oncopeltus fasciatus*) were kept in fully-pedigreed lab populations for over two years, bred either randomly ( $N_e \approx 9$ ) or using mean kinship coefficients to maximally retain gene diversity ( $N_e \approx 18$ ). Parent-offspring regressions were used to estimate changes in  $V_a$  for wing color after one year. Founding and final populations were also sub-sampled and subjected to truncation selection; cumulative selection differentials and responses were compared with controls to estimate total changes in  $V_a$  for wing length. Results suggest that carefully managing pedigrees in captive populations can on average slow the loss of evolutionary potential, though this appears to depend on the trait in question.

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## ADAPTATIONS TO ISLAND LIFE: SEED DISPERSAL BY BLACK HOWLER MONKEYS IN DEGRADED TROPICAL FOREST FRAGMENTS.

Deforestation in Guatemala continues to convert vast expanses of forest ecosystems into a series of isolated fragments surrounded by agricultural lands. The natural regeneration of these forest fragments is poorly understood. While

howler monkey seed dispersal has been established as an integral component in primary forest maintenance, their potential role in the regeneration of degraded forest habitat has not yet been investigated. I studied black howler monkey (*Alouatta pigra*) troops in variably degraded forest “islands” to determine: (1) forest degradation effects on seed dispersal ecology, (2) natural regeneration potential, and (3) resource requirements and survival adaptations of this endangered species. Detailed information was gathered on the relationship between howler behavior (foraging ecology, habitat use, seed dispersal patterns) and forest composition (vegetation surveys, phenology cycles) in each fragment. Results revealed significant differences in comparison to primary forest seed dispersal patterns, including decreased dietary diversity, increased seed predation rates, and shorter seed dispersal distances. Differences in seed dispersal patterns between the study fragments reflected differences in available forest resources. In general, it appears that forest composition, size, contiguousness, and degree of human impact are the critical factors causing howler monkey seed dispersal to decrease in effectiveness with increasing levels of forest degradation.

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GENETIC CONSERVATION OF MONTEREY PINE: THE CHALLENGE OF TRUE ISLANDS, FOREST FRAGMENTS, AND BOUTIQUE FORESTS.

The extant natural range of Monterey pine (*Pinus radiata*) consists of three disjunct mainland populations along the central coast of California and two Mexican islands off Baja California. The species is enigmatic, having enormous international significance as a highly productive exotic plantation species, but little commercial value domestically. Similarly, there is much concern internationally for the native gene pools but relatively little nationally. Monterey pine has experienced many influences that could affect the amount, nature, and structure of genetic variation. Mainland populations have experienced habitat loss, forest fragmentation, interruption of natural processes, introduction of diseases and invasive plant species, and genetic contamination from planted trees. The island populations are particularly affected by introduced biota. Conservation is complicated by the diversity of ownership and competing land values. Recommendations for genetic conservation include establishing genetic reserves, studying fine-scale genetic structure, assessing effects of genetic contamination, and delaying the deployment of artificially selected seedlings until the genetic basis for the selected traits is better understood. Recently, a forest ecology cooperative has been organized to provide a forum for scientists and forest managers to discuss conservation management of Monterey pine forests and to more effectively use science in the service of conservation.

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FIRE, FERTILITY, AND HERBIVORE EFFECTS ON CHINESE TALLOW (*SAPIUM SEBIFERUM*) INVASION OF COASTAL PRAIRIE.

Chinese tallow tree (*Sapium sebiferum*) is an aggressive alien invader throughout much of the southeastern United States and seriously threatens the biological integrity of the endangered coastal prairie ecosystem. Woody invasions of grasslands are frequently controlled by use of prescribed fire. However, we predicted that infrequent burning may promote *Sapium* establishment and growth particularly in areas with abundant soil resources and few herbivores. To test these hypotheses we designed a full-factorial experiment with 24 100m<sup>2</sup> plots examining three burn regimes (annual spring fire, single spring fire, no fire) and two nutrient treatments (additional 4g NPK/m<sup>2</sup>, control). Following spring burning we transplanted eight *Sapium* seedlings in each whole plot and randomly assigned factorial subplot exclusions of vertebrate (cage, no cage) and invertebrate (spray, no spray) herbivores. *Sapium* growth was significantly increased by an interaction between the first fire and soil nutrients. Vertebrate herbivore removals also significantly increased *Sapium* growth. Because intermittent fire appears to promote *Sapium* invasion, particularly in areas with abundant soil resources and few herbivores, our results suggest that controlling *Sapium* invasion will require either frequent burning or a prescribed mowing regime when burning is not possible.

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CUBAGUA'S PEARL-OYSTER BEDS: THE FIRST DEPLETION OF A NATURAL RESOURCE BY EUROPEANS IN THE AMERICAS.

Interdisciplinary approaches to understanding the causes and mechanisms of depletion of natural resources provide powerful tools in conservation biology. That is the case for neoextinctions. I report what was the first depletion of a natural resource in the American continent by Europeans: the pearl-oyster (*Pinctada imbricata*) beds off the coast of the island of Cubagua, Venezuela, early in the Sixteenth century. I reconstructed the historical events as well as the economic and political background that led to that depletion. I estimated the level of exploitation. Based on the

natural history of that mollusk species as well as on its competitor, the turkey-wing mussel, *Arca zebra*, I hypothesize about the reasons that led to the depletion of the pearl-oyster and why it did not recover. I conclude that the exploitation of the pearl-oyster beds was unsustainable because of its intensity and local ecology. I also conclude that (a) this type of overexploitation results in gross violations of human rights; (b) the benefits of this type of exploitation are short-lived, and (c) they favor foreign interests and/or local elites to the exclusion of native population. Lessons of these type of historical precedents should be considered by policy makers.

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A MULTISPECIES APPROACH TO ENDANGERED SPECIES CONSERVATION AND MANAGEMENT IN SOUTH FLORIDA.

The South Florida Multi-species Recovery Plan is a landmark plan by the U. S. Fish and Wildlife Service that is designed to recover 68 federally listed species in south Florida using an ecosystem approach. Not only does this region of Florida support a diverse array of flora and fauna but it also includes one of the fastest growing human populations in the United States as well. I developed a series of multispecies conservation value (MCV) maps that prioritizes conservation and management based on the habitat suitability and risk of extinction for each these species. I computed the community-level risk of extinction for a site and assigned an MCV using a spatially-explicit weighting of the species-specific habitat suitability maps by their respective species-specific extinction risks. The results highlight areas that are of greatest importance to the most vulnerable species. The resulting MCV provides an independent measure of the value of a particular site based on its ecological components, i.e., species, and the threats facing it. This method provides an important tool to prioritize conservation and recovery actions as well as evaluate land preservation alternatives.

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POPULATION AND REPRODUCTIVE TRENDS OF NENE IN HAWAII'I VOLCANOES NATIONAL PARK, 1989-1999.

The Hawaiian Goose, or Nene (*Branta sandvicensis*), is an endangered species endemic to Hawai'i. Hawai'i Volcanoes National Park, located on the island of Hawai'i, contains about 20% of all Nene in the state. To determine population trends, we summarized population estimates and reproductive success of Nene in the park from 1989 to 1999. We also pooled reproductive data across years to determine overall reproductive success at several sites within the park. Population estimates generally increased throughout the decade, from 153 birds in 1990/1991 to 203 in 1997/1998. Mean hatching success was 67.1%, whereas mean fledging success was only 29.2%. Fledging success varied among sites, from 0% at Mauna Loa and Kipuka Kahalii to 77.8% in the coastal area. Populations increased during the study, possibly due to intensive predator control. However, recruitment remained low because of starvation, dehydration, and depredation of goslings. Nene that were found at some sites within the park had higher reproductive success, probably because those sites contained more nutritious food for adults and goslings. Managers should encourage nesting at more productive sites and improve or restore habitat at poorer sites.

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ASSESSING THE IMPACT OF BOATING ACTIVITY ON SPINNER DOLPHINS, *STENELLA LONGIROSTRIS*, IN MIDWAY ATOLL.

A behavioral study was conducted in September 1999 - November 1999 and May 2000 - August 2000 in Midway Atoll, National Wildlife Refuge to assess the impact of anthropogenic disturbance caused by boating activity on the movements of Hawaiian spinner dolphins, *Stenella longirostris*. Midway Atoll NWR, turned over from the U.S. Navy to the U.S. Fish and Wildlife Service in 1996, is currently accessible to the general public. The atoll's lagoon supports eco-tourism, recreational diving and recreational sportfishing. Subsequently, the frequency of dolphin-vessel interactions, which was historically low has increased dramatically. Dolphin movement patterns were studied with theodolite tracking; variables examined included mean leg speed, linearity and reorientation rate of dolphin pods. Significant differences were detected in mean leg speed between "no boat", "boat" and "post-boat" conditions with an increase in mean leg speed during the "boat" condition. Reorientation rates significantly decreased and linearity significantly increased in "boat" conditions indicating that dolphins swim more quickly, on a straighter course and

change direction less frequently in boat presence than in boat absence. I present a description of the immediate effects of vessel traffic on dolphin movement and address the long-term implications these have on the conservation efforts of free-ranging marine mammals.

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#### USING MULTIPLE STABLE ISOTOPES TO DETERMINE THE BREEDING ORIGINS OF A NEOTROPICAL MIGRANT WARBLER.

Over the past few decades, Neotropical migrant birds have shown marked changes in abundance in many parts of their breeding range that may be due to events occurring in the breeding grounds, the wintering grounds, or during migration. To determine at which points along the migratory cycle avian populations are most at risk, it is critical to link the breeding and wintering ground events for individual species by understanding where populations of birds go. We use the naturally occurring ratios of stable carbon, hydrogen, and nitrogen isotopes in feathers to explore the breeding origins in a Nearctic-Neotropical migratory bird. Furthermore, we develop a simple multivariate model to predict the breeding region for birds of unknown breeding origins. Our results suggest that birds from all parts of the breeding range migrate throughout the wintering range, but a greater proportion of birds from the northern breeding region winter on the more westerly islands, while a greater proportion of the birds from the southern breeding region winter on the more easterly islands. Understanding such regional differences in migratory patterns will be important for determining why birds in some areas of North America are showing population declines, while in other areas populations are increasing.

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MITOCHONDRIAL DNA SEQUENCE, MORPHOLOGY AND ECOLOGY YIELD CONTRASTING CONSERVATION IMPLICATIONS FOR TWO THREATENED BUCKMOTHS (*HEMILEUCA*: SATURNIIDAE). Units of conservation interest are frequently identified using morphological or ecological characters. These characters are assumed to accurately represent phylogenetic relationships in many organisms. We tested this assumption using two species groups in the moth genus *Hemileuca* (Saturniidae). The Bog Buckmoth (*Hemileuca* sp.) is listed as threatened in New York state. The Electra Buckmoth (*H. electra electra*) is restricted to the coastal plain of southern California, where urban development in the Los Angeles-San Diego corridor has greatly reduced its habitat. However, no conservation efforts have been raised on behalf of *H. electra electra*, possibly because superficially similar populations occur just to the east where development is not as threatening. We sequenced 624 base pairs from the Cytochrome Oxidase I gene from five populations of the Bog Buckmoth and across the range of the Electra Buckmoth. We then compared the phylogenetic status of both taxa with their conservation situations. The resultant mtDNA phylogenies strongly contradict previously held assumptions about relationships in both species groups. We suggest that some exploration of genetic relationships should be undertaken when populations are threatened and considered for legislative protection. This study illustrates the importance of assessing systematic relationships using independent characters in the conservation of biodiversity.

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#### A “BIGGEST BANG FOR THE BUCK” ANALYSIS OF APPROACHES TO RECOVERING PACIFIC SALMON—ADDING REAL BUCKS.

In practice, priorities for conservation actions are informed by an ad hoc mixture of biological data, demographic theory, economic information, and politics. Our analyses are aimed at combining ecological and economic principles that can form a more truly cost-effective basis for choosing recovery actions. Using Pacific salmon as a case study, our approach is to choose the set of conservation actions that 1) maximize annual rate of population growth (?), and 2)

satisfy a budget constraint (i.e., the total cost of the chosen set of actions must be less than or equal to the budget). In contrast, we also cast the problem as one of minimizing the cost of achieving a certain level of conservation measured in ecological terms. We explore the “biggest bang for the buck” results of various conservation actions that are being considered as part of a recovery strategy for Pacific salmon. We contrast the effectiveness of such conservation actions as reductions in harvest, changes in hydropower operations, and improvements in habitat quantity or quality. Explicitly incorporating the economic costs of implementing management actions into an analysis of their effectiveness in achieving biological goals changes the rank order of priorities based on biological criteria alone.

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PREDICTING SUCCESS OF FRESHWATER FISH INTRODUCTIONS WORLDWIDE.

To understand factors influencing invasion at a global scale, I examined patterns of international transfers of freshwater fishes, using first introductions from one country to another as reported in FishBase. In multiple logistic regression, five factors explained 9% of the variation in establishment of 958 cases. Establishment was high for small-sized fishes and for omnivores. Establishment rose with endemism of the recipient country's fish fauna. Early introductions were more likely to establish (1950-1960: 68%) than were recent introductions (>1985: 13%). Species were also more likely to establish if humans intended their establishment (71%), rather than cultivated or used them with no explicit desire for naturalization (51%). Two factors (distance transferred and recipient diversity) proved unrelated to establishment. The multiple regression model was used to predict the invasion risk of an additional 197 introductions. Of the 50 cases predicted to have highest invasion risk, 92% established, whereas only 32% of the 50 least-risky introductions established. These correlates of international fish invasions reinforce current ideas that invasion risk is high for generalist, high-r species transferred into isolated environments. Apparent time lags and the higher rates of establishment for released than imported fishes, support the role of propagule pressure in invasion.

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A MICROSATELLITE ANALYSIS OF THE *EX SITU* POPULATION OF THE ST. VINCENT PARROT (*AMAZONA GUILDINGII*): MANAGEMENT RECOMMENDATIONS AND CONSERVATION IMPLICATIONS FOR NEW WORLD PSITTACINES.

Microsatellite loci were isolated within the St. Vincent parrot (*Amazona guildingii*), an endangered island endemic, from a GT<sub>n</sub> enriched genomic library. Nine polymorphic loci were characterized varying from two to nine alleles per locus. Seven loci exhibited levels of heterozygosity ranging from 39-100% within the 28 individuals genotyped. The polymorphic microsatellite markers were used to characterize the genetic structure of the captive population of *A. guildingii* on St. Vincent. The repercussions of past management strategies were evaluated and recommendations were set forth for future pairings based on genetic relatedness. On a wider scale, the microsatellite primers were demonstrated to cross-amplify within four genera of Neotropical parrots, indicating the potential utility of these markers to further population-level studies and conservation efforts of New World Psittacines.

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GENOMICS STUDIES OF GREAT APES: IMPLICATIONS FOR CONSERVATION.

Following completion of the draft human genome sequence, efforts in re-sequencing genes and identification of sequence variation within *Homo sapiens* will occupy many genome sequencing laboratories. Identification of SNPs (single nucleotide polymorphisms) will produce closely linked markers to many human diseases. DNA sequence information from species closely related to humans, e.g., *Pan paniscus*, *P. troglodytes* and *Gorilla gorilla*, will allow determination of ancestral character states for human SNPs. Comparison of human and great ape gene and regulatory region sequences will provide insights into the molecular basis for human disease and contribute to efforts to design therapeutic approaches. While some human populations have developed approaches to protecting the value of their genetic information, genetic information from chimpanzees and gorillas may be gathered and utilized for the benefit of humans without benefit to these species. Fortunately, significant new insights into the evolution, behavior and health of great apes may derive from human genomic studies. However, the opportunity to link conservation action for great apes with biopharmaceutical technology developments represents an underdeveloped dimension of the sustainable conservation and development paradigm. Genetic resource collections may contribute to research oriented toward conservation and to providing benefits for *in situ* conservation programs for great apes.

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#### PREDICTING EXTINCTION RISK WHEN POPULATION GROWTH IS DENSITY DEPENDENT.

Several recent studies point out simple extinction risk models based on diffusion approximation (DA) of population growth produce unreliable, imprecise estimates of extinction risk metrics as a result of simplifying assumptions about the underlying dynamics of the population in question (e.g. density independent growth or no observation error). We used time series data from simulated populations to evaluate the effect of varying levels of density dependence on the performance of DA models in predicting extinction risk over a variety of potential life history characteristics (population growth rates) and levels of process error. In all cases, population growth was density independent but limited by an upper ceiling. Predictions from DA models about the mean time to a 50% decline for populations with high ceilings (weak density dependence) were conservative often underestimating observed times to similar declines in the simulated data. However, as ceiling size was reduced and the strength of density dependence increased, predicted mean times to a 50% decline became decreasingly conservative even underestimating similar declines in the simulated data. Our results suggest that caution be used when interpreting predictions from simple extinction risk models when imperiled populations experience density dependence.

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#### COLLABORATORY ON THE POPULATION BIOLOGY OF INVASIVE SPECIES.

Population biology is the a link between ecology and evolutionary biology, and the synergism arising from combining ecological, genetic, and evolutionary perspectives on invasive species may be essential for developing practical solutions to the economic and environmental losses resulting from these species. Invasive species also offer unique opportunities to study basic processes in population biology as natural experiments where processes may occur far more rapidly than those in purely native systems. The Collaboratory on the Population Biology of Invasive Species was funded by the National Science Foundation to highlight the particular role that population biologists can play in the study of invasive species.

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#### ADAPTIVE MANAGEMENT: A TOOL FOR CONSERVATION PRACTITIONERS.

Adaptive management is growing in popularity as a concept in conservation circles. The purpose of our research was to determine how to make adaptive management a practical tool for conservation practitioners around the world. We first reviewed related concepts in fields including science and philosophy, social learning, business management, professional practice, and ecosystem management to create a research framework. We then field-tested this framework by visiting conservation projects in Zambia, Papua New Guinea, and British Columbia that all use some elements of an adaptive management approach. Based on this work, we define adaptive management as “a process of incorporating research into conservation action. Specifically, it is the integration of conservation project design, management, and monitoring to systematically test assumptions in order to adapt and learn.” Our research revealed that adaptive management must be done by project managers themselves. It requires establishing a clear purpose, developing an explicit model of the project site, selecting actions that maximize results and learning, developing and implementing a monitoring plan to test assumptions, analyzing data, and communicating results, and then using these results to adapt and learn. Effective adaptive management requires promoting curiosity and innovation, valuing failures, expecting surprise, capitalizing on crisis, and creating learning organizations.

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#### CONSERVATION OF ARBOREAL MARSUPIALS IN PAPUA NEW GUINEA: THE RELATIVE EFFECT OF DOGS AND FLASHLIGHTS.

Recently the pressure on wildlife populations by local hunters in New Guinea has increased with the adoption of western economy and technology. Human populations have increased, and wildlife is sold more often in markets, while hunting technology has changed. Trained local personnel from the Sokamin village, Papua New Guinea, conducted interviews for a year aimed at determining the impact of flashlights and dogs on arboreal marsupials of the area. Results from 370 hunting reports show that most encounters were casual (74.6%), and most times dogs found the animal (58.6%). Only rarely flashlights were used (15.1%). Also, although not traditionally considered hunters, women

made a significant percentage of the kills (32.9%). Those arboreal marsupials that are frequently found by dogs in, on, or close to the ground were most commonly killed. These are usually the largest (>1500g, %88.4 vs. <1000g, 11.6%), slower growing species and thus most likely to show hunting-mediated depletion due to their life-history strategies alone. Conservation plans and educational programs in Papua New Guinea should emphasize the increased pressure on the large species of arboreal marsupials and target them as priorities for conservation. This includes all species of tree kangaroos and large cuscuses found on the island.

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#### SHOULD MARINE RESERVES BE SELECTED BASED ON SPECIES RICHNESS?

Marine reserves have been identified as an essential component of marine conservation strategies, however, there has been very little scientific basis for their design or location. Areas of high species richness are often emphasized for biodiversity protection, yet protecting such areas may not maintain viable populations. For marine species with planktonic larval dispersal, sites that produce many larvae should, all else being equal, contribute most to overall population persistence. This study examined the relationship between intertidal biodiversity and the reproductive output of an ecologically important mollusc, *Katharina tunicata*, across 10 sites in Barkley Sound, BC, Canada. Reproductive output was based on area-specific gonad biomass, which was estimated from *Katharina* density, size structure and a length-fecundity relationship based on a subsample of 69 individuals. Overall estimated gonad mass varied by a factor of 5 across sites. Species richness ranged from 30 to 47 species per site. The estimated reproductive output of *Katharina* subpopulations and species richness were significantly negatively correlated ( $n = 10$ ,  $r = -0.649$ ,  $p < 0.05$ ). This case study indicates that if species richness is used as a reserve selection criterion, reserves may not include sites contributing to the persistence of particular species.

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#### CHANCE AND PATTERN IN THE STRUCTURE OF GALÁPAGOS FINCHES.

Can patterns be discerned from absence/presence data such as that obtained from island communities? Here I demonstrate a methodology for extracting patterns from species' co-occurrences. Species pairs that co-occurred more (or less) frequently than expected by chance alone were then analyzed using natural history data. All other species' co-occurrences could have arisen from chance expectations and so did not require a process-based explanation. Those species pairs that co-occurred less often than expected by chance were found to have mandible widths and depths that differed by more than 16%, while those species that co-occurred less often than expected by chance had similar mandible widths or depths. No clear relationship of co-occurrence pattern with body masses or evolutionary relationships was found. Null models and natural history data form a powerful methodology for investigating the possible role of separating mechanisms in avian distributions where those distributions differ from chance expectations.

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#### ABUNDANCE AND SURVIVAL OF RESIDENT AND MIGRATORY WARBLERS ALONG A CLOUD FOREST SUCCESSIONAL GRADIENT, WEST MEXICO.

Humid pine-oak and cloud forests of Mexico are one of the most important habitats to conserve for migratory and resident warblers in the Neotropics. However, management recommendations are lacking because basic information on the effects of forest disturbances on bird population processes are unknown. We conducted over 30,000 mist-net hours and 758 point-count of sampling of cloud forest birds in the Sierra de Manantlán Biosphere Reserve over the course of four years (1995-1999). Six species were common in early successional vegetation, and nine species in midsuccessional and mature cloud forest. Four species were common in all habitat types, and nine were too rare to classify. Wilson's warbler showed age and sex segregation by habitat, with males and adults being significantly more common in forested habitats than in early secondary stages. Adult males showed also size segregation; larger individuals being more common in mature forests. No difference in survival and recapture rates were detected among habitats for this species. Resident Slate-throated Warblers showed differential survival by habitat. Survival was lower

in early successional vegetation and this effect was more pronounced in juveniles and females. Juveniles in mature forest achieved survival levels similar to those of adults.

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THE ENDEMIC SPECIE BLACK-BREASTED PUFFLEG EXTANT BUT SERIUOSLY THREATENED .

The Black-breasted Puffleg *Eriocnemis nigrivestis*, one of the world's most threatened hummingbirds, is only found in two adjacent volcanoes in Northwestern Ecuador. This species inhabits montane forest where it appears to be confined to ridge-top vegetation. I carry out an exhaustive search for *E. nigrivestis* from October 2000 to January 2001. I visited most of the sites where it has been previously recorded. In addition, I conducted observations during walks at selected sites or in places where I set several hummingbird feeders. During this period, I only found one female at 2800 m at Verdecocha that was feeding in a large tangle of *Macleania* sp. (Ericaceae). *E. nigrivestis* was difficult to find because of its low population density, its seasonal movements and the delayed blooming of its feeding plants. Additionally, slope vegetation is being cleared intensively for pastures and firewood, principal source of income for local people. The Ornithological Foundation of Ecuador (CECIA) is developing a conservation program designed to teach residents the use of land and the creation of nurseries with native species for reforestation. This is the basis for future initiatives oriented to improve the sustainability of the regional natural resource and the protection of the biological biodiversity.

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Apartado Postal 70-275.

BIODIVERSITY INFORMATION SYSTEMS AND THEIR APPLICATION TO CONSERVATION.

Invasive species represent the second most important threat to Biodiversity after habitat destruction. Numerous groups, particularly in island systems have dissapeared due to the displacement by exotic introductions. The problem has prompted action by countries in the context of the Convention of Biodiversity and a number of preventive measures have been recommended for adoption world-wide. An additional approach to help deal with this significant problem is to predict areas of distribution, and therefore possible environmental and Biodiversity impacts, of introduced, invasive species. An application of GARP and similar methodologies to predict potential niches for species is presented and examples of its utilization are discussed, particuarly for the threat to *Opuntia spp.* represented by the spread of a moth (*Cactoblastis cactorum*), which did not exist before in North America and was introduced into the Antilles as a biological control. Many of the *Opuntia* species under threat are endemic to Mexico and constitute keystone species to extenses ecosystems of the arid and semiarid regions of the country. (EITHER)

SATO, PAULINE, and Aulani Wilhelm. The Nature Conservancy, M? lama Hawai'i, USA.

MÄLAMA HAWAI'I – BUILDING A PUBLIC CONSTITUENCY FOR CONSERVATION IN HAWAI'I

Mälama Hawai'i -- meaning "to care for and protect Hawai'i" -- is a partnership dedicated to ensuring that Hawai'i is a place where the land and sea are cared for and communities are healthy and safe. The major thrust of Mälama Hawai'i is to mobilize people toward meaningful action by linking conservation issues with health, culture, education, and the economy. As a first step, Mälama Hawai'i has conducted a statewide telephone market research survey to more than 600 residents to gauge public attitudes toward environmental conservation. From this baseline information, we are developing a series of public awareness initiatives with themes that will make caring for nature relevant to people's lives, directly linking conservation to shared community goals, well-being and quality of life. This will be integrated with a volunteer stewardship network, which will provide "hands on" opportunities to directly mälama Hawai'i. Our long term goal is for Mälama Hawai'i to be a dynamic forum that connects people and organizations to their communities, economy and culture in a manner that sustains Hawai'i's environment.

SCHEFFLER, PAMELA Y. The Pennsylvania State University, Department of Biology, 208 Mueller Labs, University Park, PA 16802, USA.

MOSAIC ISLANDS: SCARAB BEETLE (COL: SCARABAEINAE) COMMUNITY STRUCTURE IN AN AMAZONIAN FOREST FRAGMENT.

Habitat fragmentation is increasingly common in the neotropics as more land is modified for human use. The objective of this study is to understand how changes in the vegetative structure of an area affect community structure and dynamics in other groups. The study was conducted in a typical Brazilian Amazon forest island surrounded by pasture. The fragment is approximately 8,500 ha<sup>2</sup> which has been further fragmented internally by the creation of a network of roads, selectively logged areas and clearcut areas. Scarab beetles (Coleoptera: Scarabaeinae), a group known to be sensitive to habitat modification and indicative of changes in other taxa, were trapped in intact forest, selectively logged forest, clearcuts and pasture. Individuals from each area-type were identified to species, measured

and weighed, and differences between the areas were compared. Intact and selectively logged areas were similar to each other in terms of species composition, richness and diversity, and biomass; many of the indices declined with decreasing forest cover. A single non-native species was encountered in the pasture areas only. In conclusion, increased forest disturbance in the Amazon is leading to a simplified scarab community with increased opportunity for invasion of non-native species.

SCHLAEPFER, MARTIN A. Section of Ecology and Evolutionary Biology, Fernow Hall, Cornell University, Ithaca, NY 14853-3001, USA.

#### SURVIVAL OF A NEOTROPICAL LIZARD ALONG PASTURE-FOREST GRADIENTS; EGGS DO WELL WHERE ADULTS DON'T.

Edges have become a common feature of many landscapes because of wide-spread habitat fragmentation. I tested the idea that forest species may experience reduced survival in the vicinity of edges or in adjacent pastures. I estimated the survival of eggs and adults of a neotropical lizard, *Norops polylepis*, across pasture-to-forest gradients in the vicinity of Las Cruces, Costa Rica. I sampled three different sites. Each site spanned from 45m into the pasture (from the edge) to 150m into the forest and was sampled intensively three times at approximately 6-month intervals. Survival of adults (n=1026), estimated via mark-recapture sampling, was lower in the pastures (probability of surviving a 6-month period = 0.25) than in the forests (0.39). However, *Norops polylepis* eggs (n=56), obtained through captive breeding, developed 30-40% faster and were more likely to hatch (p=0.05) in the pasture than in the adjacent forests. These results suggest that the warmer pastures are beneficial to the development and survival of the eggs. Adults may be attracted to the pastures for this reason, but experience a lower survival there, raising the possibility of an ecological trap.

SCHUMAKER, NATHAN H., and Ted Ernst. U.S. Environmental Protection Agency, 200 SW 35th Street, Corvallis, OR 97333 (NHS), Dynamac Corporation, 200 SW 35th Street, Corvallis, OR 97333, USA (TE).

#### MODELING WILDLIFE RESPONSE TO LANDSCAPE CHANGE IN OREGON'S WILLAMETTE RIVER BASIN.

The PATCH simulation model was used to predict the response of 17 wildlife species to three plausible scenarios of habitat change in Oregon's Willamette River Basin. This 30 thousand square-kilometer basin comprises about 12% of the state of Oregon, encompasses extensive forested and agricultural lands, and is home to 68% of the state's population. 1990 landscape conditions were represented with a 30-meter resolution GIS map that contained 34 habitat types and was derived from classified satellite imagery. In addition, three images for year 2050 were developed that showed how the basin might look if existing land use practices remained in effect, if management shifted to emphasize development, and if policies changed in favor of increased conservation. A literature survey produced sufficient survival, reproduction, and movement data to conduct PATCH simulations for 17 birds and mammals, and the model was run for each of the species and the four landscapes. Response to the changing landscapes varied greatly between the species. Attempts to anticipate the model predictions using measures of habitat quality met with varied success, and the failures provide detailed theoretical examples of how a simple population viability analyses might fail to meet its conservation goals.

SCHWARTZ, JESSE D.M., Marla J. Pallin, William O. Ojwang and Les Kaufman. Biology Department, Boston University, Boston, MA 02215, USA.

#### THE EFFECTS OF NILE PERCH, *LATES NILOTICUS*, ON FUNCTIONAL DIVERSITY IN THE LAKE KYOGA SATELLITE SYSTEM, UGANDA.

The introduction of Nile perch, *Lates niloticus*, to Lake Victoria, East Africa, facilitated a drastic reorganization of the lake's food web and the extirpation of hundreds of species of endemic fishes. Much of Lake Victoria's fish diversity can now be found only in satellite refugia such as those adjoining and near lake Kyoga where both lakes with and without Nile perch can be found. During the summer of 1999 we surveyed six lakes in the Kyoga system using quantitative gill nets (1/4"-1" diagonal stretch) to investigate the effects of Nile perch on functional diversity and ecological relationships. We used gut content analysis, previously published research, and ecomorphological inference to assign trophic levels to all fishes encountered, and related this to  $\delta^{15}\text{N}$  values. Trophic level, fish length, and taxonomic status combined explained more than 92% percent of the variance in  $\delta^{15}\text{N}$  (PCA: p<0.001). Lakes without Nile perch had greater taxonomic diversity (t-test of Simpson's D: p=0.046), and an overall greater number of recognizable trophic groups suggesting the ecological relationships of these lakes is more intact than those with perch. The Kyoga system is a boon for comparative study and has much to lend to our understanding of the conservation of functional diversity.

SCHWARTZ, MICHAEL K., L. Scott Mills, Kevin S. McKelvey, and Leonard F. Ruggiero. Wildlife Biology Program, University of Montana, Missoula MT 59801 (MKS, LSM), USDA/USFS Rocky Mountain Research Station, Missoula, MT 59801, USA (KSM, LFR)

#### HIGH GENE FLOW IN CANADA LYNX LEADS TO THE MAINTENANCE OF GENETIC VARIATION ACROSS THE LANDSCAPE.

Populations on the periphery of a species geographic range are often given less conservation consideration because it is thought that they maintain lower levels of genetic variation and are likely to have lower probabilities of persistence. However, recent evidence shows that peripheral populations are not necessarily the first to disappear during species range contraction. Furthermore, it is possible that peripheral populations have unique attributes, both morphologic and genetic, worthy of conservation efforts. We explore whether peripheral populations of Canada lynx (*Lynx canadensis*) have reductions in genetic variation using nine microsatellite DNA markers, 17 populations and 599 lynx. Our results show a slight depression in genetic variation in peripheral populations of Canada lynx. Furthermore, this reduction of genetic variation is in the face of high levels of gene flow between core and peripheral populations ( $F_{st} = 0.038$ ). These results have strong implications for the management of this threatened species; specifically they suggest that international efforts must be initiated to maintain gene flow to southern U.S. populations.

SCOTT, J. MICHAEL, T.L.C. Casey, and Robert Shallenberger. U.S. Geological Survey, Moscow, Idaho (JMS); Bishop Estates, Hilo, HI, USA (TLCC) and U.S. Fish and Wildlife Service, Honolulu, HI, USA (RS).

#### PREDATORS AS LIMITING FACTORS IN RECOVERY OF ENDANGERED SPECIES: ARE THE SCALES OF MANAGEMENT ACTIONS CONSISTENT WITH THE THREAT?

Non-native predators have been identified as limiting factors for many of the currently listed endangered and threatened species. Recovery plans often target removal of predators or reduction in their numbers as a necessary step in meeting recovery goals. Review of endangered species recovery efforts suggest that the scale at which these control efforts are implemented are often significantly smaller than the population unit of interest i.e. population, meta-population subspecies, species. Comparisons of the status of species for which the scales of predator control efforts and distribution of the predator differed will be made Implications for future management actions on behalf of endangered species will be discussed.

SCOTT, J. MICHAEL. U.S. Geological Survey, Department of Fish and Wildlife, University of Idaho, Moscow, ID, USA.

#### CONSERVATION UNITS GENES TO ECOSYSTEMS: WHAT ARE WE PROTECTING? SPECIES AS A TYPE OR EVOLUTIONARY POTENTIAL?

The Endangered Species Act allows for protection of species, subspecies and distinct population segments. Conservation assessments often focus on species or ecosystems as the targets of conservation, less often subspecies or a distinct population segment. In this talk I will review past conservation assessments and identify the units evaluated and to what extent we have been successful in capturing the range of variation found in conservation targets. Examples from North America, Hawai'i and Australia will be used to illustrate points.

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#### RESTORING HIGH-ELEVATION MESIC FOREST—THE EFFECT OF *ACACIA KOA* ON SOIL NITROGEN.

Overcoming the harsh climatic, edaphic, and biotic conditions that exist in deforested, alien-grass-dominated landscapes between 1700–2000 m elevation in Hakalau Forest National Wildlife Refuge, Island of Hawai'i, is prerequisite for restoring forest habitat for threatened and endangered species. *Acacia koa*, which is the only native tree species that easily establishes in the grassland, may ameliorate harsh conditions and create habitats that are favorable for establishment of stress-intolerant native species. The objective of this study was to quantify the effect of young stands of *A. koa* on soil nitrogen pools and the microbial-mediated transformations that regulate pool sizes.

Ammonium-N and nitrate-N pools were determined using standard KCl extracts. Gross rates of N mineralization, immobilization, and nitrification were determined using a modification of the  $^{15}\text{N}$  dilution method. Data were collected for soil under grass, young *A. koa*, and nearby mature forest. Ammonium-N pools were largest under young *A. koa* and nitrate-N pools were largest under mature forest. Rates of microbial production and consumption of  $\text{NH}_4$  and  $\text{NO}_3$  generally increase in grassland soils after establishment of *A. koa*. Microbial competition for ammonium was strong; that for nitrate was generally weak. Grassland soil on slopes was nitrogen limited and *A. koa* alleviated the limitation.

SECOR, CAROL L., and Thomas E. Dowling. Department of Biology, Arizona State University, Tempe, AZ 85287, USA.

#### CRYPTIC LINEAGES, HYBRIDIZATION AND CONSERVATION OF A SOUTHWESTERN FISH.

Species with complex evolutionary histories provide a challenge for prioritizing conservation units. Fishes illustrate these difficulties effectively because species often hybridize after substantial genetic divergence. One such taxon, the Zuni bluehead sucker (*Pantosteus discobolus yarrowi*) from the Little Colorado River (LCR) drainage of Arizona and New Mexico, is listed as threatened by the State of New Mexico and considered a species of special concern by the State of Arizona. Taxonomic relationships between this subspecies and other members of the genus, however, are unclear. Previous studies have provided evidence of hybrid origin, a unique lineage, or both. We evaluated these alternatives using mitochondrial and nuclear gene sequence data from suckers collected throughout the LCR. All three loci examined indicated that a unique lineage of *Pantosteus* (sister to *P. discobolus*) occurs in the LCR, but alleles from two other forms of *Pantosteus* (typical *P. discobolus* and *P. plebeius*) were also present. Comparisons among populations indicated that some were fixed for LCR alleles, while other populations contained mixtures of alleles from two or more forms. Therefore, identification of appropriate conservation units was confounded by divergence in mitochondrial haplotypes and variation in the nature and level of hybridization among geographically isolated populations.

SEETO, P. S. Conservation International. P.O. Box 106, Waigani, NCD, Papua New Guinea.

#### THE BIOLOGICAL, SOCIO-ECONOMIC AND POLITICAL ISSUES INFLUENCING THE ESTABLISHMENT OF COMMUNITY-BASED MARINE PROTECTED AREAS IN MILNE BAY PROVINCE, PAPUA NEW GUINEA: EXPERIENCES AND LESSONS

The community-based coastal and marine conservation project in Milne Bay (Papua New Guinea) aims to conserve a representative sample of global marine biodiversity and promote the sustainable-use of Milne Bay's marine resources through the establishment of a network of community-based marine protected areas (MPAs). The project to date, has involved thorough assessments of the biological, socio-economic, legislative and political issues that are necessary for the selection of potential sites and the long-term success of the project. Conservation International's rapid inventories of marine biodiversity in conjunction with existing biological data highlighted priority areas for the conservation of biodiversity and commercially-exploited species. Of critical importance to the project is the fact that customary tenure system recognizes local community control of marine resources, hence, a participatory approach has been integrated right from the start into the project design and planning and will continue during implementation and after establishment of the MPAs. The long-term success of the project will also involve the development of meaningful community-based protective and enforceable regimes nested within the country's existing legislative framework. This paper outlines the project's progress to date, including experiences and lessons learned during the initial stages of establishing community-managed MPAs in Papua New Guinea.

SEHGAL, RAVINDER N. M., Hugh I. Jones, and Thomas B. Smith. Center for Tropical Research, Department of Biology, San Francisco State University, 1600 Holloway Ave., San Francisco, CA 94132, USA (RNMS, TBS), Dept. of Microbiology, University of Western Australia, Nedlands, Australia (HIJ), and Center for Population Biology, University of California Davis, Davis, CA 95616, USA (TBS).

#### HOST SPECIFICITY AND PREVALENCE OF *TRYPANOSOMA* IN SOME AFRICAN BIRDS; A MOLECULAR APPROACH.

Studies of host-parasite interactions in birds have contributed greatly to our understanding of the evolution and ecology of disease. Here we employ molecular techniques to determine the incidence and study the host-specificity of trypanosomes in the African avifauna. We developed a polymerase chain reaction (PCR)-based diagnostic test that amplifies the small subunit ribosomal RNA gene (SSU rRNA) of *Trypanosoma* from avian blood samples. We use the test to describe the incidence of trypanosomes in 479 individuals representing seventy-one bird species in rainforest habitats of Cameroon, the Ivory Coast and Equatorial Guinea. Thirty-two of the bird species (59%) harbored trypanosomes, and 189 individuals (35%) were infected. We sequenced the amplified SSU rRNA and found a high degree of sequence diversity in *Trypanosoma*, but found little trypanosome-lineage specificity across either avian hosts or geographic locations. Based on morphology, we identified two trypanosome species in these hosts, and found 7 different haplotypes in the one morphospecies *T. avium*. We found that birds from different habitats, collected over a wide distance range, were infected with a single haplotype, and several haplotypes could be detected at a single location. We discuss the possible ecological and conservation implications of these host-parasite interactions.

Seibels, Robert, Kevin J. Bell, STEVEN D. THOMPSON, and Joanne M. Earnhardt. Riverbanks Zoological Park and Botanical Garden, Columbia, SC (RS); Lincoln Park Zoo, 2001 North Clark Street, Chicago, IL 60614, USA (KJB, SDT, JME)

#### WHEN WORLDS COLLIDE: WOES OF THE BALI MYNAH CONSERVATION PROJECT.

The Bali mynah (*Leucopsar rothschildi*) is one of the world's most endangered birds. Endemic to the island of Bali, its current distribution is restricted to Bali Barat NP, where fewer than 30 birds remain in the wild. From 1987 to 1996, international recovery efforts for this species met with mixed success: multiple recovery plans were developed, tested and/or partially implemented. Key components of these plans were anti-poaching campaigns, economic disincentives to the pet trade, and a reintroduction program. Despite these efforts, the wild population remained between 10-50 individuals. In 1997, the American Zoo and Aquarium Association's Species Survival Plan (SSP) brought stakeholders and experts together for a series of meetings to reinvigorate the moribund anti-poaching and reintroduction components of the recovery plan. Meeting participants identified attainable goals and objectives, assumed responsibilities for specific actions, and committed substantial start-up funding. Nevertheless, the SSP and its collaborators were unable to implement the plan. Subsequent setbacks, including unscheduled reintroductions, reintroductions of sick birds, multiple thefts of birds from the park's captive breeding center, and an overall atmosphere of political and logistical confusion effectively curtailed all but the most metaphysical efforts to implement a cohesive *in situ* conservation effort for this species.

SEMPLE, KATHLEEN, and Robert K. Wayne. University of California, Department of Organismic Biology, Ecology and Evolution, 621 S. Charles E. Young Dr., Los Angeles, CA 90095-1606, USA.

#### POPULATION STRUCTURE OF ISLAND SCRUB JAYS (*APHELOCOMA INSULARAIS*).

Island scrub jays (*Aphelocoma insularis*) are endemic to Santa Cruz Island, one of California's Channel Islands. The island was presumably colonized by western scrub jays (*Aphelocoma californica*) from California, although the time, size of founding population and number of colonization events is unknown. Estimation of the ancestral population size number of founding events and number of founding individuals was assessed using coalescence theory. Coalescence theory can be used to study the evolutionary history of samples by looking backwards in time to the most recent common ancestor of focal samples. By sequencing 566 base pairs of the control region of mitochondrial DNA from both scrub jay species, we were able to generate gene genealogies, which were used for coalescent analysis. We found large sequence divergence between the two species and island scrub jays formed a monophyletic group within the *Aphelocoma* jays. These results are consistent with the recent re-classification of island scrub jays as a full species. Insights into the evolutionary history of endemic island scrub jays will aid in the conservation of this sensitive species.

SHAMBAUGH, JAMES. Biodiversity Support Program, c/o WWF, 1250 24<sup>th</sup> Street NW, Washington, DC 20037, USA.

#### MITIGATING THE IMPACTS OF ARMED CONFLICT ON THE AFRICAN ENVIRONMENT: STRATEGIES FOR THE CONSERVATION COMMUNITY.

Armed conflict represents a major threat to biodiversity conservation across wide areas of sub-Saharan Africa, posing unique challenges for conservation organizations attempting to work in these areas. This paper presents the lessons learned from a three-year study conducted by the Biodiversity Support Program's "Armed Conflict and the Environment project" to examine the impacts of armed conflict on biodiversity in sub-Saharan Africa. Drawing from an extensive literature review, interviews with experts and conservation practitioners in the field, and case studies from ten areas of conflict in Africa, this paper highlights key constraints and opportunities facing conservation organizations working in conflict areas, focusing on innovative approaches and strategies for achieving conservation objectives. This paper briefly examines the impacts of armed conflict on the environment in sub-Saharan Africa, including habitat destruction/loss of biodiversity, over-exploitation of natural resources, and pollution. It then describes the consequences for conservation, including loss of local/national control over natural resources, interruption of on-the-ground activities, stagnation of policy making and implementation, and withdrawal of donor support. In conclusion, this presentation provides a set of practical tools and guidelines to help conservation organizations maintain their effectiveness during periods of conflict by integrating conflict mitigation into planning processes and strategic programs.

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#### SURVIVAL AND MOVEMENTS OF A REINTRODUCED BALD EAGLE POPULATION.

Bald eagles (*Haliaeetus leucocephalus*) disappeared from the California Channel Islands by the early 1960's, primarily because of DDT contamination in the marine environment. DDT was outlawed for use in the U.S. in 1972 and other

bird species that had been negatively impacted were recovering by the late 1970's. In an effort to reestablish bald eagles on the California Channel Islands, 77 bald eagles were released on Santa Catalina Island between 1980 and 2000 either by hacking or by fostering young into wild nests. Birds were equipped with transmitters and wing-markers to provide an opportunity for long-term monitoring. Adults are non-migratory, but approximately half of the young of the year leave the island, often returning later in life. Released eagles were detected as far away as British Columbia and Montana. Thirteen juvenile eagles (17%) are known to have died in the nest or during their first year of life and 17 birds (22%) are known to have reached breeding age (5-6 years). Although adult survival has been high, residual DDT contamination has precluded successful hatching of eggs in the nest, demonstrating how unforeseen factors, such as environmental contaminants, can significantly impact successful restoration.

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**DETECTION OF POPULATION TRENDS IN THREATENED COHO SALMON (*ONCORHYNCHUS KISUTCH*).** Populations of coho salmon (*Oncorhynchus kisutch*) in California are listed as threatened under the US Endangered Species Act. Such listings refer to adult populations, but often juvenile life history stages are censused, so it is important to understand what affects the relationship between true adult and observed juvenile numbers. We present models to address how observational uncertainty, census length, autocorrelation in vital rates and density dependence affect our ability to observe trends. We ask two questions about our ability to detect declines in one life history stage from censuses of another. First, given an observed decline in parr numbers, what is the chance this reflects a decline in adults? Second, given adult numbers are declining, what is the chance that we see that decline in parr? Our results indicate that statistical power decreases with increasing observational uncertainty and decreasing census lengths, and demonstrate how these two parameters interact. Power increases as the level of autocorrelation in mortality rates increases. Density dependence in any life history transition hampers detection of trends. Management recommendations include obtaining more accurate estimates of autocorrelation in mortality, and of observational uncertainty.

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**ASSESSING NATIVE PLANTS AS POTENTIAL FOOD ITEMS FOR THE HAWAIIAN GOOSE OR NENE (*BRANTA SANDVICENSIS*).**

The endangered Nene (*Branta sandvicensis*) is the last remaining endemic goose in Hawai'i, numbering less than 1000 birds statewide. Nearly thirty years after intensive captive breeding and restocking efforts began in Hawai'i Volcanoes National Park, the population of Nene remains low due to poor reproductive success in the wild. Contributing factors include inadequate nutrition resulting in high gosling mortality and low numbers of adults attempting to breed. A project was initiated in December 1999 to identify high quality native food plants for augmentation of Nene brooding areas and larger scale habitat rehabilitation. A database of all known and suspected nene food plants was compiled using publications, field notes and personal communications. Endemic, indigenous and Polynesian introduced species were selected from this list of 75 species and 18 were collected and analyzed for nutritional content. Ten potential food species were also sent for analyses. Twelve species contained adequate levels of protein and fibers to sustain satisfactory growth in young goslings. These species were propagated and the plants tested for palatability in trials with young goslings (0-4 weeks). All species were eaten by goslings. However, several species, including *Agrostis avenacea*, *Digitaria violascens* and *Oxalis corniculata*, were consumed more frequently and completely.

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**BIRD MOVEMENTS ACROSS HABITAT BOUNDARIES OF RIPARIAN BUFFER STRIPS.**

Fragmentation of riparian habitats can have negative impacts where remaining fragments fail to support certain forest-dwelling bird species. One possible mechanism of population decline is the reluctance of certain species to move across habitat boundaries. To assess bird habitat use in a forest/clearcut matrix, I compared bird communities across 19 sites on western Vancouver Island representing buffer fragments of varying widths on one side of the river. During 1998, I evaluated bird movements across two types of habitat boundaries: 1) forest and adjacent clearcut and 2) forest across rivers. I compared the tendency and frequency of crossing habitat boundaries as a function of buffer width. I hypothesized that birds would move more freely across river edges compared to clearcut edges and that movements

across both edges would be higher in narrow buffers dominated by ubiquitous and edge species. Preliminary results show movements are negatively associated with buffer width. Narrower buffers have the highest frequency of movements both into clearcuts and across rivers. Densities, though similar among buffer widths, were more variable in narrow buffers. Preliminary results suggest that narrow buffers may function primarily as foraging sites or movement corridors rather than suitable nesting areas.

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#### EVOLUTION OF INCREASED COMPETITIVE ABILITY IN AN INVASIVE TREE SPECIES.

Invasive plants are often more vigorous in their introduced ranges than in their native ranges. This may reflect innate superiority of plants from some habitats or escape from their enemies. Another hypothesis proposes that invasive plants evolve increased competitive ability in their introduced range. We present here results of a 14 year common garden experiment with Chinese Tallow Trees (*Sapium sebiferum*) from its native range (Taiwan), place of introduction to North America (Georgia) and areas colonized a century later (Louisiana and Texas). Native genotypes were least vigorous but had the highest quality, best defended leaves. Invasive genotypes were more vigorous with lower quality, less defended leaves, especially genotypes from recently colonized areas. Grasshoppers preferred to feed on Texas genotypes. Our results are the clearest evidence to date of ecologically significant evolutionary change by an invasive plant in its introduced range. They suggest that post-invasion adaptation by invasive plants may contribute to their success, utilization by native herbivores and the effectiveness of biological control agents.

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#### DEMOGRAPHIC AND BEHAVIORAL RESPONSES TO POPULATION COMPRESSION IN AN ENDANGERED, ISLAND PRIMATE.

Fewer than 2,000 Zanzibar red colobus monkeys remain. They are limited to fragmented habitat on the island of Zanzibar and are threatened by habitat loss and degradation. We used data collected from 1992-1999 to determine (1) if a 2-fold increase in red colobus density during this period was due to habitat loss, population compression and immigration of groups into the study area (composed of pasture, perennial agriculture and regenerating secondary forest) or due to intrinsic growth and (2) the demographic and behavioral correlates of this population increase. Data were collected using scan, focal, and *ad libitum* sampling during full-day follows of 8-12 red colobus social groups. Demographic data show that the increase in density was due to immigration. Groups in the compressed population were more cohesive, had smaller home ranges with greater home range overlap, and exhibited higher levels of inter- and intra-group aggression than groups in the adjacent more mature forest. In contrast, natality and survivorship of juveniles remained unchanged following increased population densities. This demographic stability may be related to ecological succession in the study area as it changed from agriculture to secondary forest.

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#### HOW MUCH DOES THE POPULATION BIOLOGY OF INVASIVE SPECIES MATTER TO THEIR CONTROL?

The literature on introduced species is rather dichotomous, with much of the invasion biology literature in "academic" journals such as American Naturalist or Biological Invasions and much of the management literature in "applied" journals, especially in insect and weed management. This dichotomy leads to the question of the extent to which detailed population biology can inform management of introduced species. Some striking successes of introduced species management seem devoid of profound population biological understanding, and many others, though resting on important natural history or other biological facts, do not seem to require extensive understanding of population biology. Further, many introductions that could probably have been quickly stemmed ultimately went out of control because of demands for deeper study of whether they were likely to become horribly invasive. There may also be an element of hubris in believing that a list of population biological traits can predict an invasion trajectory well enough to be used in permitting decisions. Although invasion biology of the population biology persuasion is an exciting and intellectually rewarding field, a frank appraisal of its utility to management is warranted.

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POPULATION STRUCTURE AND HISTORY IN THE WORLD'S LARGEST FRESHWATER INVERTEBRATE - THE TASMANIAN GIANT LOBSTER.

The world's largest freshwater invertebrate, the Tasmanian Giant Lobster (*Astacopsis gouldi*) is a highly endangered freshwater crayfish. Because of the enormous sized reached by this crayfish (> 5 Kg), it is prized by fisherman. This crayfish is known only from streams in the north of Tasmania. The narrow distribution, pollution of habitat, and over-harvesting has lead to the rapid decline of populations of this species. Consequently, there are conservation initiatives being implemented to stave off extinction for this unique animal. Here we present the first genetic data on this species and use these data to examine the degree of population subdivision among populations. This is invaluable information for the future successful management of this species, both in terms of historical knowledge of population structure and in planning restocking activities.

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#### INVERTEBRATES ON KAPITI ISLAND POST RAT ERADICATION - PATTERN OR PIGGELDY?

Kapiti Island is a large (1965ha) is land off the West coast of the North Island, New Zealand. Removal of rats was required to restore it's biodiversity. In September and October 1996, rodents were poisoned using aerially distributed cereal bait laced with brodifacoum (Talon). Invertebrates were monitored pre and post rat eradication from 1995 until 1999 using pitfall traps in ten sites across the island. Sites ranged in vegetation from forest to open grassland. Samples were taken in spring, summer and winter. Invertebrates >5mm were sorted and counted for abundance. Data were analysed using the simple diversity measures and mathematical modelling with indicator groups and indicator species. There were over 370 morpho-species recorded from this study. There was no sudden increase in invertebrate abundance after eradication. Site to site variation, and seasonal variation were the largest confounding factors. Different groups of taxa responded differently e.g. Amphipoda abundance varied seasonally but Isopoda did not. A decline in richness occurred from 1997 to 1998 that coincided with an El Nino year, and a four fold increase in insectivorous bird fauna. Conservationists should consider the effort (vs the information return) that is required when monitoring recovery of invertebrates in the short term.

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#### IMPACTS OF LANDSCAPE CHANGE ON MOBILE ANIMALS: EFFECTIVE AREA MODELS FOR CONSERVATION PLANNING.

Habitat fragmentation is changing terrestrial landscapes at unprecedented and increasing rates. Impacts on animal populations are difficult to predict because the complexity of the resulting landscape mosaic exerts influences that are not captured by simple assessments of habitat area and condition. In fragmented landscapes, habitat edges are dominant features that influence the distribution and abundance of many species. Estimates of population-level responses may be improved by accounting for the species' differing responses to edges and the juxtaposition of habitats. We present a spatial modeling approach, incorporating empirical data on animal edge responses, that predicts changes in animal abundance under explicit landscape configurations and management scenarios. Inputs to the model include habitat maps and animal density response functions. Each response function describes animal density in terms of a probability distribution along a habitat gradient stretching between the interiors of adjacent habitat patches. For many species, predictions of this Effective Area Model differ from those of a null model that does not incorporate edge effects, often by a factor of two or more. Initial tests of model predictions for birds and butterflies in two arid ecosystems indicate that the EAM is significantly better at predicting the abundances of many edge-sensitive animals.

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#### AVIAN NEST SUCCESS IN VARIEGATED AND HIGHLY FRAGMENTED PRAIRIE LANDSCAPES.

Understanding the influences of habitat fragmentation on the viability of declining species is essential to conservation planning. This study examines the influence of prairie fragmentation on declining grassland birds of the central shortgrass prairie of North America. I measured mortality of natural and artificial nests and vegetation structure in 42 sites in variegated (62% grassland remaining) and highly fragmented (38% grassland remaining) landscapes of northeastern Colorado. In the variegated landscape, daily mortality of artificial nests was greater in fragmented than intact grassland sites and was positively related to grass height and density. Daily mortality of artificial nests in the highly fragmented landscape was also negatively associated with patch size and positively associated with grass height and density. In the highly fragmented landscape, however, mortality of Lark Bunting (*Calamospiza melancorys*) and

Horned Lark (*Eremophila alpestris*) nests increased significantly with increasing patch size. The artificial nest experiments described nest mortality patterns in small patches (< 30ha) in which few natural nests were found. I hypothesize that prairie fragmentation has differential effects on predator species, resulting in different primary predators in small and large habitat patches.

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#### THE EFFECTS OF WAR ON CONSERVATION OF A WORLD HERITAGE SITE IN THE DEMOCRATIC REPUBLIC OF CONGO.

The World Heritage Sites of the Democratic Republic of Congo have been affected by wars, both in neighbouring countries and within their own country, for several years. At Garamba National Park on the north-eastern Sudan, border of the country, not only has active protection of the park continued as far as possible throughout these wars, but ranger based law enforcement monitoring has also continued. This has enabled a clear evaluation of the relationship between resource exploitation and wars and their effects on the wildlife of this National Park. By relating indicators found to patrol effort expended, results are obtained that can be comparable between sites, regions and over time. The war in Sudan to the north of the park has increasingly fueled meat poaching, particularly since 1991. Moving from the remote north to the better protected south this has led to a marked differential in large mammal distribution. The first civil war through 1997 reduced protection effort to less than a quarter of the previous years' effort, and over half the large mammals were lost. In the initial phases of the second war, in late 1998 and early 1999 anti poaching continued with very little reduction and mammal numbers remained relatively stable. Graphs and GIS mapping are used to demonstrate the effects in detail. This poster presentation illustrates the reasons that the patrol guards of the Institut Congolais pour la Conservation de la Nature have gained this year's group Distinguished Service Award from the Society for Conservation Biology.

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#### ECOTONES AND RAINFOREST DIVERSITY: CURRENT TRENDS AND CHALLENGES.

Recent studies on diverse vertebrates suggest that transition zones between rainforest and savanna (ecotones) are important areas of diversification. In Africa two lines of evidence support this: First, the ecotone between Central African rainforest and savanna is an important contact zone for avian taxa. Second, recent studies of bird species show evidence of strong morphological divergence despite gene flow between forest and ecotone populations, a central component of speciation models. While data continues to accumulate to suggest that ecotones are important areas of diversification – and therefore areas of conservation importance -- there is little available data on the magnitude of anthropogenic threats (including forest conversion to agriculture, grazing, logging and fire). To understand how forest fragments that characterize the ecotone may be changing over time, a combination of remote sensing and mapping techniques were undertaken. Three vegetation indexes from Landsat TM and MSS data were used to examine changes over the past thirty years. Results indicate a loss of ecotone vegetation at the edges of gallery forests near human settlements, but a gain in rainforest vegetation in regions with low human densities. The implications of these findings to both biodiversity and carbon stock are discussed.

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#### CHANGES IN RELATIVE ABUNDANCE AND DIET OF *LONTRA LONGICAUDIS* RELATED TO RAINFOREST DISTURBANCE IN CHIAPAS, MEXICO.

Otters have been used as bioindicator species of river disturbance. They inhabit rivers and streams of clear, unpolluted water surrounded by pristine vegetation, having relatively high abundance of prey. Our study focuses in the neotropical river otter (*Lontra longicaudis*) in four streams of the Lacandona Rainforest in Mexico: two covered by natural vegetation inside the Montes Azules Biosphere Reserve, and two in communal land under agricultural-cattle ranching use and impact. We located otter latrines and collected feces for diet analysis on a two year basis. Feces were counted per stream, this indicates otter relative abundance. Stream water was analyzed for pesticides and abundance of coliform bacteria. Although otters were present in all four streams, their relative abundance was much greater in the conserved streams. Concomitantly, the disturbed streams had much greater abundance of coliform bacteria and pesticides. The diet is constituted primarily by fish and crustaceans. Unusual terrestrial prey for otters, were only found in the disturbed streams. The rivers' water where otters are abundant may be much more suitable for human use than

water where otters have been extirpated. Our study supports the idea that otters are good bioindicators not only of vegetation disturbance, but also of water quality.

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#### CONSERVATION PLANNING FOR A SPECIES-RICH, DATA-POOR ECOREGION.

Conservation planning for the south-western Amazon, one of the world's few largely intact ecoregions, is complicated by the fact that information on the distribution of biodiversity is poor. To develop a long-term conservation plan for this 700,000 km<sup>2</sup> tri-national area, we created a proxy for beta-diversity based on climate, soils, and a coarse-level vegetation map. We then set an objective of representing at least 10% of all the resulting landscape units in protected nucleus areas. Minimum size of these nuclei was set at 500,000 ha on the basis of minimum area requirements for viable sub-populations of area-sensitive species such as the jaguar and harpy eagle. To help locate conservation areas, we developed a "conservation opportunities" grid by combining layers of anthropogenic data individually weighted according to their predicted impacts on achieving habitat protection. Negative layers were proximity to population centers, infrastructure, and deforested areas, and positive layers were proximity to existing and proposed protected areas. The resulting analysis identified 26 nucleus areas, totaling 180,000 km<sup>2</sup> (25% of the ecoregion), that if protected would capture the ecoregion's habitat heterogeneity. If connections were sufficient to permit gene flow, these areas should protect the ecoregion's biodiversity in perpetuity.

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#### VEGETATION-BASED CONSERVATION OF INSECT COMMUNITIES: A TEST AT TWO SCALES WITH BOLIVIAN DUNG BEETLES.

Conservation planning based on vegetation communities is a widespread strategy throughout the world. This approach assumes that the ecological structure and spatial arrangement of faunal communities closely mirror vegetation patterns. Previous tests of this assumption have suggested that insect communities may correspond well with large-scale vegetation types such as forest, shrubland, and grassland, but not with finer divisions within these vegetation types. I evaluated the correspondence of tropical dung beetle and vegetation communities at two scales: among 5 vegetation classes and 11 subclasses. Dung beetle communities were sampled at 33 sites within Parque Nacional Noel Kempff Mercado in eastern Bolivia. All 28,991 dung beetles collected were referenced by site and identified to species. Analysis of similarity (ANOSIM) of dung beetle communities indicated significant differences between vegetation subclasses and classes, but distance between sites was not significant. Cluster analysis of the sites suggested that the clearest divisions between the dung beetle communities were among vegetation classes, specifically between upland savanna, seasonally inundated savanna, deciduous forests, and a lumped class of upland and inundated evergreen forests. My results suggest that vegetation classes provide a reasonable basis for conserving dung beetle communities in the tropics, even if those classes are relatively broad.

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#### AHUPUA'A, A TRADITIONAL LAND DIVISION, AS A MODEL FOR INTEGRATED RESOURCES MANAGEMENT.

Ahupua'a are traditional land divisions which were devised by the people of old Hawai'i as a means of organizing the landscape. Ahupua'a link the biogeographic regions of heaven and earth according to the economic and political sensibility of traditional Hawai'i. The archetype runs from the interior of the island to a prescribed place in the near shore waters. Understanding of the hydrologic cycle is implicit, including the relationship between watershed and climate. But ahupua'a are more than arcane relicts of old Hawai'i, title to every parcel of real estate in Hawai'i is recorded according to the ahupua'a in which it is situated. Thus, an important paradigm of planning for economic productivity and sustainability of natural resources awaits being recognized as sensible once again.

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#### INTEGRATING MANAGEMENT OF ALIEN PREDATORS IN HAWAII VOLCANOES NATIONAL PARK.

Introduced alien rats and yellowjacket wasps are a major cause of biodiversity loss in New Zealand and Hawai'i. These two groups of alien predators differ in biology, but their impact and control have many parallels that lend themselves to co-management in native ecosystems. In the fall of 1999, control methods for both species were tested in Hawai'i Volcanoes National Park. Yellowjacket control was evaluated in September, using minced chicken meat containing 0.1% fipronil placed in 45 bait stations 25 m apart on a 9 x 5 grid in replicated 2-ha sites. Yellowjacket activity at their nests declined by 98% two days after treatment, while activity in non-treatment sites increased. The efficacy of hand-broadcasted fish-flavored cereal baits containing 0.005% diphacinone (Ramik<sup>?</sup> Green) was also evaluated for controlling rats beginning in October in separate 4-ha sites. Rat numbers based on pre- and post-treatment live trapping declined from 29 to 0 in the diphacinone-treated site, while they increased from 32 to 47 in the non-treatment site. Integrating these two control methods would result in an approximately 40% reduction in labor costs. Decision-support models are being developed to aid in joint management of these two predators in mesic forests in the park.

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#### FRAGMENTATION OF THE SHORTGRASS PRAIRIE: EFFECTS ON SMALL MAMMALS AND GRASSLAND BIRD NEST PREDATION.

Birds endemic to the central shortgrass prairie have experienced widespread declines in the past three decades. While the causes for these declines have not been identified, in a 1997 study nesting success of birds on fragmented shortgrass prairie sites was exceptionally low when compared to unfragmented (intact) sites. One explanation for this pattern is that vegetation structure or surrounding land uses on fragmented sites supports denser populations of small mammals, which depredate nests of ground-nesting grassland birds. In this study, I compared vegetation structure, small mammal densities, and nest predation rates on fragmented and intact shortgrass prairie sites, and edge (the shortgrass/cropland interface) and interior sites. There were few differences in vegetation structure between sites. Small mammal densities and species richness did not differ between fragmented and intact sites, but were greater on edge sites than interior sites. No differences in artificial nest predation rates were found. However, a strong positive linear relationship between density of thirteen-lined ground squirrels and artificial nest predation rates was found in 1998 and 2000. Density of natural nests was lower on edge sites than on interior sites, and predation rates on natural nests appeared to be greater on edges than interiors.

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#### INVASION OF MAUI, HAWAII, BY THREE SPECIES OF *FICUS* (MORACEAE): BIOTIC INTERACTIONS AND CONSEQUENCES.

A desire by foresters to enhance forest cover of watersheds in Hawai'i resulted in numerous tree introductions in the first half of the 20<sup>th</sup> century. In order to assure the spread of introduced *Ficus* spp., successful efforts were made in the 1920s-1930s to establish the specific wasp pollinators for *Ficus microcarpa* (Chinese banyan), *F. cf. platypoda* (Port Jackson fig), and *F. macrophylla* (Moreton bay fig). Vehicle surveys of roads in conjunction with walk-through surveys of known infestations resulted in detailed distribution maps for *Ficus* on the island of Maui. *F. microcarpa* and *F. cf. platypoda* have now become widespread invaders at low elevations on Maui, and *F. macrophylla* is starting to spread. Effects to date include damage to water-transporting infrastructure, displacement of lowland vegetation, and smothering of host trees (e.g. *Acacia koa*) after epiphytic establishment. To date, most seed dispersal has likely been by common lowland alien birds with relatively small home ranges, such as common mynah (*Acridotheres tristis*). Incipient establishment of parrot-like birds, including mitred conures (*Aratinga mitrata*), on Maui is likely to accelerate invasion of *Ficus*. Moreover, establishment and spread of *Ficus* may facilitate further invasion of non-native frugivores.

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RESTORING WHAT LITTLE IS LEFT OF THE BIRDLIFE IN REMOTE OCEANIA.

Human colonization led to the extinction of most species of birds in Oceania. Documented by thousands of bones from prehistoric sites on 70+ islands, the landbirds hardest hit were megapodes, rails, pigeons, parrots, and passerines. Most surviving species occur on only a fraction of the islands where they once lived. No “Jurassic Park” scheme can ever bring back the species already lost, but a program of translocation has much potential to save some surviving species whose futures are not bright. Most Pacific islands are poorly suited for translocation because of habitat degradation (deforestation, proliferation of non-native plants) and the presence of multiple species of non-native predators. Nevertheless, certain uninhabited islands still support substantial forest and lack most or all forms of non-native predators. These islands should be targeted for translocations, even if done with some biogeographic impurity, i.e. occasionally using islands lacking evidence for former residency of the translocated species. Beggars cannot be choosers. Practicalities and natural history should outweigh genetic and biogeographic theory in designing and implementing the translocations, which can be accomplished in a low-tech, low-budget fashion. Rome is burning; armchair arguments about theoretical issues will not save species of birds in the tropical Pacific.

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#### NEW CONTRIBUTIONS TO THE BIOGEOGRAPHY OF NEW GUINEAN MAMMALS.

The biogeography of most New Guinean mammals remains poorly studied. We report results of a survey from the only protected area in the most biologically diverse region of New Guinea, and a new revision of museum databases and collections. The survey site, Mt. Stolle, is in Papua New Guinea’s Telefomin Region, Sandaun Province. Methods used to survey mammals included a variety of traps, spot-lighting, and hunters’ trophies. We revised the American Museum of Natural History database and collection of marsupials and monotremes by place names to exact collection locations in reports of the Archbold Expeditions (1933 to 1964). We also reviewed the entire marsupial and monotreme database and collection at the Australian Museum, and the entire marsupial and monotreme collection at the PNG National Museum and Art Gallery. We found new altitudinal limits for 35 species, and 6 new species accounts for Sandaun Province. Our data suggest that the Telefomin region, at just 1.3% of New Guinea’s landmass, hosts at least 37% of its mammal species and 45% of its endemic mammals. Our review demonstrates the potential for relatively small, protected areas to contribute to overall biodiversity conservation of the world’s largest tropical island.

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#### SALVAGE LOGGING OF POST-FIRE FORESTS: BREAKING THE CHAIN OF INVERTEBRATE AND BIRD COLONIZATION.

We studied the effect of post-fire salvage logging on vegetation, invertebrate, and bird communities in Alberta’s boreal forest. Immediately following a 1998 fire, 21 - 10ha sites were established in three different treatments: burned/unlogged; burned/salvage-logged; and unburned/unlogged. The most significant difference in vegetation among our treatments was a greater number of snags (standing dead trees) in the burned/unlogged forest. Biomass of wood-inhabiting invertebrates was significantly greater in the burned/unlogged forest both the first and second year post-fire. *Picoides* woodpeckers (hairy, downy, three-toed, and black-backed) were found in greater numbers in the burned/unlogged forest compared to the other treatments, during a two-year post-fire sampling period. Within the burned/unlogged forests, numbers of woodpeckers varied seasonally (being greater in the winter months), and declined over time. However, the abundance of secondary cavity nesting birds increased in the second year post-fire. We suggest that snags provide an important link in post-fire colonization by invertebrates, followed by woodpeckers, followed by secondary cavity nesters. Salvage logging removes the snag component and breaks this chain of post-fire colonization. Present government policy encourages the large-scale removal of post-fire forests for timber production, and may be detrimental to these communities.

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#### INTEGRATED CONSERVATION BIOLOGY TRAINING MATERIALS.

Producing conservation biologists in countries where most of the world’s biota resides would greatly lessen the biodiversity crisis, yet conservation biology programs in tropical countries lack support and relevant materials in an appropriate language of instruction. In response, we are designing and fostering the implementation of an integrated set of conservation biology training modules at the undergraduate, graduate, and professional levels for universities in

tropical countries. Each module will contain an expert summary of a topic, a collection of the original scientific literature for each topic; a set of visual presentations for use in lectures; and an extensive problem-solving exercise. Instructors will be able to select from and adapt an array of topics to fit a particular academic situation. We envision this as a community effort, and hope to integrate contributions from many conservation scientists and educators. Collectively, the modules will provide a resource for developing single or multiple, field- or classroom-based courses. Modules will be translated into several languages, starting with English, Spanish, and French. A critical component of the project is a mentoring program to help instructors master and customize the materials to suit their needs. The first set of modules and mentoring initiatives were tested in Bolivia.

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#### EFFECTS OF MULTIPLE FIRES ON RARE PLANTS OF HAWAII AND NATIVE HAWAIIAN SHRUBLANDS.

In July of 1994 and August of 1999, a fire was ignited in a *Pennisetum setaceum* grassland on the leeward side of Hawaii. The fires entered the Kipuka Kalawamauna Endangered Plants Habitat Area of the U. S. Army's Pohakuloa Training Area and burned approximately 1,700 hectares (65%) and 1,300 hectares (48%), respectively. Recovery of woody and herbaceous plant species in two shrublands were measured following each fire. Preburn data was available for the same areas. Impact of burning on, and recovery of, three rare plant populations (*Haplostachys haplostachya*, *Stenogyne angustifolia*, and *Tetramolopium arenarium*) also were monitored. Following the first fire, woody and herbaceous plant cover and density had returned to preburn levels. The dominant native grass, *Eragrostis atropioides*, recovered more rapidly than did the introduced species, *P. setaceum*. There was no significant increase in density of *P. setaceum* following the first fire. Vegetative recovery following the second fire has been much slower. Species richness declined following each fire and has not returned to preburn levels. *H. haplostachya* and *S. angustifolia* vigorously sprouted following the fires, while *T. arenarium* populations were gone following the second burn. All three rare species were significantly browsed by feral ungulates.

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#### A DIETARY INVESTIGATION OF CO-ROOSTING ENDEMIC AND ENDANGERED LARGE FLYING FOXES IN THE PHILIPPINES.

The U.S. Navy in 1992 left Subic Bay, Luzon, Philippines, transferring some 10,000 hectares of now rare lowland forest to local control after a century. The area contains one of the last large colonies of the endangered, endemic Golden Crowned Flying Fox (*Acerodon jubatus*), the largest bat in the world (by weight, ca. 1 kilo plus). The dietary composition of this species and the Philippine Giant Fruit Bat (*Pteropus vampyrus lanensis*) it roosts with were studied using fecal analysis, hunter interviews, and personal observations. Proportion of bat droppings having elements from the *Ficus* genus averaged 74% (76% *A. jubatus*; 71% *P.v. lanensis*) over a seven month period. Of all *Ficus* seeds identifiable to the species level, one species, *Ficus variegata*, showed high degrees of representation in bat droppings (31% *A. jubatus*; 55% *P.v. lanensis*). Results suggest that a limited number of fig species comprise a staple in both bat species' diets throughout the year, while a number of other dietary items are also utilized on sequential basis by *P.v. lanensis*. Results of this research are being utilized to effect species selection in reforestation efforts to benefit the Golden Crowned Flying Fox and to reduce hunting pressure on this species.

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#### NEW PROGRAM IN TROPICAL FOREST ECOSYSTEM AND AGROFORESTRY MANAGEMENT AT HAWAII COMMUNITY COLLEGE.

Hawaii's native forests, with more endangered species than all the other states combined, are declining due to introduction of alien species, over-harvesting of some species, and increasing use of forest land for other purposes. Former sugar land is being converted to commercial forestry and agroforestry operations. Management of both native forest ecosystems and agroforestry is creating a demand for more technicians trained in these areas. Hawaii Community College has been working in partnership with the Hawaii Community Forestry Initiative, the Workforce Development Council and the Department of Education's Natural Resources Career Pathway to develop a Certificate program and a two year A. S. degree to help meet this demand. A major goal of the grant is training in management and regeneration of Hawaii's native ecosystems. Students will learn to use GPS and GIS for forest survey and management. A significant part of the Certificate program will be internships with partners in government agencies and the private industry. The curriculum is focused on Hawaii, but is transferable to other areas in the tropical Pacific. The program will start in Fall, 2001.

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#### EFFECTS OF SELECTIVE LOGGING ON 13 SYNTOPIC WOODPECKER SPECIES IN A FOREST RESERVE IN PENINSULAR MALAYSIA.

Woodpeckers are considered sensitive to logging and deforestation because they nest in tree cavities and often forage on large trunks or standing dead trees. The diverse woodpecker community found in the lowland rainforests of Peninsular Malaysia was investigated in 5 and 10 year-old selectively logged forest and virgin forest using census, foraging, and habitat availability data. Relative abundance differed significantly between logged and unlogged forest and also between logged stands of different ages. Although woodpeckers did not respond uniformly to logging, they were generally less abundant in the 10 year-old forest. This trend, supported by an earlier study in 45 year-old managed forest, reflects a lack of heterogeneity in managed stands with relatively few snags and treefall gaps. Important foraging substrates were identified, and, combined with substrate availability data, were effective in predicting changes in abundance of individual species across forest types. The current practice of maintaining patches of virgin forest within logging concessions seems to be an effective way of conserving a diverse community of woodpeckers and other cavity-nesting birds. Maintaining a portion of snags and “overmature” trees in logged stands may help increase the abundance of species dependent on dead wood for foraging or nesting throughout the reserve.

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#### BOTTOM-UP EFFECTS ON PERSISTENCE IN A FRAGMENTED LANDSCAPE: ARGENTINE ANTS AND COASTAL HORNED LIZARDS.

Coastal horned lizards (*Phrynosoma coronatum*) have undergone severe declines in southern California. We estimated lizard distribution and abundance by establishing 256 pitfall trap arrays clustered within 21 sites across four counties in California. Factors correlated with lizard abundance included the absence of the invasive Argentine ant (and presence of native ant species eaten by the lizards), the presence of chaparral community plants, and the presence of sandy substrates. As horned lizards are ant specialists, they may be particularly vulnerable to changes in the native ant community resulting from the invasion of Argentine ants (*Linepithema humile*). We therefore examined how Argentine ants influence horned lizard growth rates by raising hatchlings on prey typical of invaded and uninvaded sites. Hatchling horned lizards maintained positive growth rates on a diet of just one native ant species (*Crematogaster californica*). However, on a diet of Argentine ants or arthropods typical of an invaded community, horned lizard growth rates were either negative or averaged near zero. While stochastic demographic and environmental processes are often invoked to explain the decline of populations post-fragmentation, it appears that horned lizards are disappearing at least in part due to the deterministic effects of a biological invasion.

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#### THE RECOVERY OF HAWAIIAN PLANT SPECIES USING OVULO AND EMBRYO CULTURE.

The Lyon Arboretum Rare Hawaiian Plant Project's mission is to prevent further extinction of Hawaiian plant species, propagate plants for use in restoration and reintroduction projects, and initiate and maintain an *in vitro* germplasm collection primarily of the “critically endangered” plants. These goals are achieved through the use of micropropagation, which is utilized when: 1) plant species are difficult to propagate using conventional methods, 2) viable plant propagules are rare due to inbreeding depression or difficulty in accessing plants, 3) plants have small, recalcitrant or immature seeds or spores, 4) poor quality propagules due to unhealthy parent stock, and 5) when *in vitro* germplasm cultures are to be established. Two techniques routinely used to establish *in vitro* cultures of seed derived explants are embryo and ovulo culture. Embryo culture is the isolation of an immature or mature embryo and its growth within a sterile culture. Ovulo culture is the establishment of an embryo with its endosperm. In many cases, embryo and ovulo culture can eliminate seed germination inhibitors, shorten the breeding cycle and prevent embryo abortion. Some of the Hawaiian genera that have benefited from embryo and ovulo culture are *Hesperomannia*, *Tetraplasandra*, *Alectryon*, *Nestegis*, *Ochrosia*, *Pritchardia* and *Kokia*.

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#### A LANDSCAPE ANALYSIS OF THE EFFECTS OF CLEAR-CUT FELLING ON THE ABUNDANCE OF THE RARE WILDLIFE SPECIES ON THE AMAMI ISLAND, JAPAN.

The wildlife species endemic to the Nansei Archipelago have been threatened by extensive clear-cutting of mature forests on the Amami Island. I counted the number of forest birds in the breeding season and the number of the fecal pellets of the Amami rabbit *Pentalagus furnessi* in order to examine the habitat quality of different seral stages. Then, multiple regression equations were obtained for each species with a certain statistical significance between the number of birds or pellets observed and the area of the mature forest, cut-over forest nearby, the percentage of young naturally regenerated forests, the percentage of plantation forests, forest age, the distance from the border between young and mature forests, etc. All these equations indicate the importance of mature natural stands to maintain higher level of the population density. The surveys suggested also that the population level of some endemic bird species is very low and some small populations of the Amami rabbit are fragmented. The mature natural forests are fragmented due to clear-cutting, though the amount of cutting have been decreased sharply for these years. It is urgent to preserve the remnant mature forests and establish some corridor reserves in order to maintain viable metapopulations.

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#### POPULATION VIABILITY OF *TAXODIUM MUCRONATUM* AN OLD GROWTH RIPARIAN FOREST FROM CENTRAL MÉXICO.

Riparian forests in Central México exhibited human disturbances that affect the recruitment and survival of riparian species. *Taxodium mucronatum* (Ahuehuete) is an old growth dominant riparian tree with ecological and cultural importance for Mexicans. A demographic and ecophysiological analysis of *T. mucronatum* populations was conducted in areas with different degrees of disturbance since 1998. Populations with more than 200 adult individuals (Diameter at breast height >10 cm) were surveyed with contiguous quadrats (10 x 10 m) in (100 x 20 m) belt transects, where all individuals were tagged and measured annually. Transition and elasticity's matrices per population were constructed with the annual radial growth, seed production and germination and survival data. Two close populations in contrasting water regime were selected in order to seasonally measure water potential and leaf area indices. Results indicated that populations in disturbed habitats had significantly decreasing trends ( $\lambda = 0.94$ ) while healthy populations not differ significantly from replacement. Elasticity analysis indicates that older trees contribute importantly for population recruitment. Trees in polluted rivers with controlled flow have significantly smaller radial growth, higher water deficit and smaller canopy than those in better conditions. Water flow pulses and treatment plants are required to sustain healthy populations.

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#### ALIEN INVERTEBRATES IN URBAN AND RURAL FOREST SOILS.

Non-indigenous soil animals in North America have received little attention compared to other taxa. Urban areas are known to be hotspots for species introduction. We surveyed and analyzed the macroinvertebrate fauna in nine forest patches within the Greater Baltimore Metropolitan Area. Non-native species clearly dominate both diversity and abundance of the soil community. Percentages of introduced species for earthworms, terrestrial isopods and millipedes are 83%, 100%, and 46%, respectively. Two species originate in Asia and the rest are European. Here we report for the first time *Lumbricus friendi* (earthworm), and *Chaetophiloscia sicula* (isopod). The latter is especially interesting, because the entire genus is new to the continent, indicating a more recent introduction. This Mediterranean species seems to survive the cold winter in the region. Earthworm species richness was highest in the rural forest, whereas abundance was greater in the urban forests. Density varied between 0 and 136 ind/m<sup>2</sup>. Native earthworms occur only in rural areas. Most isopods were collected in the city (>2000 ind. per trap). Abundance of millipedes was much lower (41 ind. per trap). High proportion of these macrodecomposers greatly influences the rate and pathways of decomposition and the structure of mesofauna and microbial community.

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#### DETECTING DIRECT AND INDIRECT EFFECTS OF FOREST FRAGMENTATION WITH GENETICS, DEMOGRAPHIC MODELS, AND EXPERIMENTS.

We used a variety of genetic, demographic, and experimental tools to examine the responses of two small mammals to fragmentation on forest fragments in southwest Oregon. California red-backed voles (*Clethrionomys californicus*) were nearly absent from clearcuts, but persisted as small, highly variable populations on forest fragments with no detectable loss of fitness. Combined genetic and demographic data show that forest islands receive large numbers of immigrants that could not be detected with field methods alone. Despite evidence that voles disperse through clearcuts, their role in re-inoculating clearcuts with mycorrhizal fungi appears limited. In contrast to voles, deer mice (*Peromyscus maniculatus*) show positive responses to fragmentation. Adult survival and population growth rates (from matrix projection models) were highest in clearcuts, intermediate on fragments, and lowest in unfragmented forests. Abundances were 3-10 times higher at fragment than unfragmented sites. Seed predation experiments suggest one indirect consequence of changes in the distribution of deer mice following fragmentation is decreased recruitment and increased extinction risk for the understory plant trillium (*Trillium ovatum*).

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ISLAND CONSERVATION IN NORTHWEST MEXICO.

The more than 250 islands in the Gulf of California and the Pacific coast of Northwest Mexico have ~230 endemic species and subspecies of vertebrates. Isolation and aridity have protected these island ecosystems from most human impacts. However, introduced mammals threaten many of their endemic birds and mammals, and may have already caused 21 extinctions. From 1995-2000 the Island Conservation & Ecology Group, National Autonomous University of Mexico, Center for Biological Investigations, and National Protected Areas Department have collaborated with local people and NGO's to remove 28 introduced mammal populations from 19 of the  $\geq 49$  islands on which they were present (9 islands  $< 1\text{km}^2$ , 7 islands  $1-5\text{km}^2$ , and 3 islands  $5-10\text{km}^2$ ). In addition, eradications are nearly completed for rats on three islands ( $< 3\text{km}^2$ ) and for cats on two islands ( $10\text{km}^2$  and  $43\text{km}^2$ ). In total, these science-based conservation actions cost ~US\$700,000 and protected 51 endemic vertebrates from the threat of introduced mammals. The main obstacles to this conservation work have been limited funding, permits, and finding skilled hunters/trappers. Introduced mammal populations remain on  $\geq 23$  islands, most of which are  $50-350\text{km}^2$ . Current eradication efforts are focused Clarión and Socorro, two of the most isolated islands with 14 endemic vertebrates.

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AN INVASIVE SPECIES INFORMATION SYSTEM FOR HAWAII AND PACIFIC ISLANDS.

No other region of the world is so devastatingly affected by invasive species as Hawai'i and Pacific islands, but the pervasiveness of the issue provides hope that it may be possible to marshal adequate resources to address the problem. Policy makers, managers, scientists, the public, and the media of the region need a recognized clearinghouse for authoritative information and contacts on invasive species issues. This clearinghouse should provide, in a readily accessible format, comprehensive, synthesized information to facilitate sound policy, effective management, and quick action. USGS' Hawaiian Ecosystems at Risk project ([www.hear.org](http://www.hear.org)) has since 1996 provided a start toward serving such a need. Information is provided at local, regional, national, and global scales. Helped by injection of funding through the Pacific Basin Information Node of the National Biological Information Infrastructure, starting in 2001, increased infrastructure and manpower are expected to be available to develop more comprehensive information storage, retrieval, and dissemination in cooperation with the Hawai'i Natural Heritage Program of University of Hawai'i and the Department of Natural Sciences of Bishop Museum. An important consideration is coordination with a central U.S. national system for invasive species information and with whatever becomes the primary international system.

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EFFECTS OF FOREST MANAGEMENT ON THE COOLEST CRITTERS ALIVE (COLEOPTERA: ELATERIDAE).

Many managers of forest lands are striving to maintain biodiversity in their forests while still reaping a profit from their harvests. The use of a wide range of harvesting systems creates forest stands that differ substantially in environmental conditions. Although insects are an important component of forest ecosystems, little is known regarding

the effects of harvesting on insect communities. We examined how click beetle (Coleoptera: Elateridae) communities are affected by tree harvesting. Click beetles were trapped at varying heights in 13 different mixed hardwood-softwood stands in central Maine, USA. We collected 59 species in 1997-1998. Most were quite rare; only eleven species reached counts of 20 or more. Elaterid community differences were observed between the various forest stands. Environmental variables such as the volume of decaying snags, vegetation species richness and diversity, vegetation structural complexity, and total vegetation biomass correlated with the abundance of individual beetle species. Because insects are sensitive to subtle differences in micro-habitat, some click beetle species may be useful as indicators of change in forest properties.

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#### RETENTION OF AVIAN COMMUNITY REPRESENTATION IN THE RIO GRANDE CORRIDOR OF NEW MEXICO.

Historic habitat changes and local resource conservation interests yielded a perception that bird species representation in the Rio Grande Corridor of New Mexico has changed markedly in the past century, especially through reduction and alteration of cottonwood-willow (*Populus-Salix*) woodlands, although corroborating evidence was lacking. We investigated avian composition, emphasizing neotropical migrant (NTM) species, in 47 vegetation communities over nearly 475 km of the Corridor floodplain. During spring, breeding season, and fall surveys of 74 transects, we detected 259 bird species, including 147 NTM species. Overall, there was >98% similarity between regularly-occurring species (all species and NTMs only) detected during our sampling and bird species reported present prior to 1900. However, historical literature review and our observations indicate 12 species appear to be declining and 14 species appear to be increasing. We detected 16 species (including 4 introduced, non-native species) not reported historically. Historical data were qualitative, thus no demographic comparisons were possible. While abundance and distribution of birds in the Rio Grande Corridor undoubtedly has changed, past characterizations of substantial loss of avian diversity were not substantiated. Retention of species representation to present day holds promise for species restoration with habitat enhancement in the Corridor.

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#### SIMULATED SOURCE SINK DYNAMICS AND FRAGMENTATION EFFECTS ON WOOD THRUSH IN EASTERN USA.

I investigated potential impacts of forest fragmentation and demographic parameters on the viability of wood thrush in the Eastern USA. I used a modified Leslie-matrix approach with separate demographic parameters specified for 110 sub-populations defined by hexagonal cells that covered the Eastern US. I calculated carrying capacity of each cell from the area of forest types in a cell and simulated fragmentation effects by assuming fecundity was negatively related to levels of forest fragmentation in a cell. I also tested the effects of various demographic values and assumptions about dispersal. Simulations demonstrated potential long-term declines in the global population resulting from fragmentation effects on fecundity. Under different assumptions about dispersal, local sink populations went extinct, persisted, or drained source populations. Forest fragmentation is a potential mechanism for the range-wide decline of an eastern forest songbird if fecundity is linked to fragmentation levels.

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#### HOMELESS DRAGONS: OPTIONS FOR ASIA'S ENDANGERED CROCODILES.

Seven of the world's 23 species of crocodylians are critically endangered. The majority (5) of these are Asian, and four share similar conservation challenges including extensive habitat fragmentation, small numbers of wild animals and relatively large captive populations. Since the 1970s conservation of the gharial (*Gavialis gangeticus*) in India and Nepal has been based largely on releasing captive-reared juveniles into limited areas of protected habitat. Human population pressures and habitat fragmentation are severe for the Philippine crocodile (*Crocodylus mindorensis*) and the Siamese crocodile (*C. siamensis*). The Chinese alligator (*Alligator sinensis*) faces the most difficult situation as it has lost virtually all its natural habitat. Captive breeding efforts for these last three species have been successful but have been conducted entirely in lieu of efforts to maintain wild populations, and all three face the possibility of

extinction in the wild and overpopulation in breeding facilities. This is particularly true for the Chinese alligator, whose fate in the wild will rest on developing novel approaches that blend captive population management, habitat restoration, and the active participation of local farming communities.

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#### EFFECTS OF FERAL PIG DISTURBANCES ON VEGETATION AND SOIL CHARACTERISTICS IN A CALIFORNIA COASTAL GRASSLAND.

Natural and anthropogenic disturbances are often instrumental in promoting the invasion of introduced species into native communities. Sometimes invasive species can themselves act as important disturbance agents where they invade, as in the case of the widely introduced feral pig (*Sus scrofa*). While foraging for underground food resources, feral pigs overturn extensive areas of vegetation and associated soils. In California, feral pig populations have increased since their introduction in the late 1700s and are now conspicuous constituents of grassland and woodland habitats. To investigate the community and ecosystem-level effects of feral pig disturbances, we used an enclosure experiment in a frequently disturbed northern California grassland. We sampled fenced enclosures and controls after four years for plant species composition, cover, biomass and soil fertility. Results show that feral pig rooting increased species richness in nonnative grass and forb taxa and increased biomass of annual grasses and non-native forbs. With increasing levels of disturbance, cover of native perennial grasses decreased while the cover of annual grasses and non-native forbs increased. Soil fertility was not affected by feral pig disturbances. These results will not only foster an enhanced understanding of grasslands in California, but will contribute to improved management of a controversial invasive species.

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#### PICKING THE PLACES TO PULL PLANTS.

New Zealand is a weedy island nation—there are over 240 environmental weeds, most vegetation types are vulnerable to weed invasion and three-quarters of the offshore islands have weeds. The New Zealand Department of Conservation does both weed-led and site-led weed control. The latter aims to protect the conservation values of special places. Our system for deciding site-led control priorities is based on the conservation values of sites—their biological distinctiveness, size and natural character. The better the site, the higher its priority for weed control. Even at high-value sites, we only control those weeds that affect the conservation values there. Weed management in low-value places is limited to newly naturalised species. We have stopped blindly chasing after weed species that we cannot eradicate or even contain. Thus, we control evergreen buckthorn on valuable Rangitoto Island but not on adjacent mainland reserves, mist flower on Hen and Chickens, home of the tuatara, and broom only at high value places such as Tongariro National Park. The lesson: confine control of widespread weeds to significant sites; tackle only those weeds that compromise conservation values at the site. Pull plants at priority places where conservation benefit is greater than perspiration expended.

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#### POINT ENDEMICITY CONFOUNDS DIVERSITY AND IMPACT ASSESSMENT FOR GASTROPOD SPECIES FLOCKS IN LAKE TANGANYIKA.

The endemic thiarid gastropods of Lake Tanganyika are famed for their morphological diversity, convergence on marine forms, and species richness. Lavigeria is demonstrably the most diverse "species flock" forming clade in this ancient rift lake, with high levels of sympatry among approximately 30 species recognized to date. These grazing herbivores are the dominant benthic macroinvertebrates in the rocky littoral zone. While some species are widely distributed along most of the 1400 km of shoreline, others are point endemics with distributions measured in kilometers or hundreds of meters. We have sampled both regionally (lake-wide) and locally to catalogue molluscan diversity, determine community composition, and test for habitat disruption. Snails are impacted by increased anthropogenic sediment accumulations on rocky substrates. Although we expect much of the point endemism is primary (local speciation), microfossils indicate that current point endemic *L. coronata* was previously found at sites now impacted. We found that previous estimates of the malacofauna seriously underestimate overall diversity through

limited geographic sampling. Moreover, species replacement even on the scale of a few kilometers makes controlled comparisons difficult for testing the effects of sediment impacts on the endemic fauna. Despite this we can show sedimentation correlates with decreased diversity on both regional and local scales.

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#### REDUCED SEED PRODUCTION AND LOSS OF GENETIC DIVERSITY IN FRAGMENTED POPULATIONS OF *TRILLIUM CAMSCHATCENSE*

The effects of forest fragmentation on seed production and genetic variation of a common understory perennial *Trillium camschatcense* were investigated in eastern Hokkaido, Japan, for two years. *T. camschatcense* occurring in this region is self-incompatible and always requires insect-pollination for reproduction. In general, small and fragmented populations experienced decreased seed production in both years of study. In addition to the population size itself, landscape types also represented significant effects on seed production. That is, populations surrounded with abundant forest series ('continuous') were likely to produce higher a number of seeds than populations located in small and isolated forest islands ('isolated'). These two types of populations with different surrounding forest patterns may differ in pollinator abundance, because decreased seed production was attributed to pollen limitation. Analysis of genetic structure based on allozyme variations revealed loss of allelic richness in small populations, while heterozygosity and inbreeding coefficient had no relationship with population size. All alleles that were not observed in small populations were rare, indicating that loss of genetic diversity may have occurred owing to founder effect at the time of fragmentation.

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#### MONITORING MATE COMPATIBILITY WHEN PAIRING CAPTIVE SAN CLEMENTE LOGGERHEAD SHRIKES.

The San Clemente loggerhead shrike (*Lanius ludovicianus mearnsi*) is an endangered subspecies endemic to one of the Channel Islands off southern California. This small predatory passerine is an aggressively territorial bird, and pairs form only during breeding season. Since 1994, CRES behaviorists have monitored the breeding behavior of the captive population in order to maximize the production of chicks for release while minimizing loss of breeding adults from aggression. Before pairing, females are placed in cages adjoining the males' cages, and each pair is observed daily for 20 min scoring for courtship, nest-building and agonistic behaviors. Male shrikes play the active role in courtship, approaching, displaying, and offering food to females. Female aggression towards the male is one measurable sign of incompatibility. Females that failed to pair had significantly higher rates of aggression. Another sign of incompatibility was food begging by captive females. In general food offers occurred without begging, but when it did occur it was more often the male who begged while offering food to females. Unlike wild pairs, captive pairs have plenty of food at close proximity and males can feed females until they are sated. Females begged when males failed to court at sufficiently high rates.

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#### VERTEBRATE ABUNDANCE AND DIVERSITY IN FRAGMENTED HABITATS OF COASTAL SOUTHERN CALIFORNIA.

Impacts from recent urbanization have created fragmented habitats along coastal southern California. In order to address habitat degradation and conservation planning, monitoring surveys were conducted in Orange County, California. Amphibians, reptiles, and small mammals were surveyed by using drift fence arrays with pitfall and funnel traps, while tracking stations were used for recording carnivore presence. A total of 12 study sites were sampled over a period ranging from 1 - 5 years. The study sites, encompassing diverse habitat types found in coastal southern California, range from sea level to elevations of 2,000 meters. The surveys within these fragmented habitats documented a total of 52 species (9 amphibians, 24 reptiles, 19 mammals) inhabiting landscapes within restricted private property to public access nature reserves. This study was useful in indicating where viable populations remain and identified which species have become more threatened in coastal southern California. By studying vertebrate communities of fragmented areas we may be able to create and design functional habitats within nature reserves, parks, and private lands in order to successfully protect vulnerable wildlife populations.

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INDIVIDUAL, POPULATION, COMMUNITY AND ECOSYSTEM CONSEQUENCES OF A FISH INVADER IN  
NEW ZEALAND STREAMS.

A challenge confronting ecologists is the integration of processes at various levels in the ecological hierarchy. A series of coordinated studies in New Zealand streams address the impact of an exotic fish on individual behavior, and on population, community and ecosystem patterns. Our approach ranges from descriptive field studies, through experimental studies in artificial channels, to comparative studies in contrasting streams. At the individual level, grazing invertebrates show changes in behavior as a result of the introduction of brown trout (*Salmo trutta*), a predator that exerts a very different selection pressure than native fish. At the population level, trout have replaced non-migratory galaxiid fish in some streams but not others. At the community level, trout suppress grazing pressure by invertebrates, enhance algal biomass and change algal species composition. Finally, at the ecosystem level, essentially all annual production of invertebrates is consumed by trout (but not by galaxiids) and algal primary productivity is six times higher in a trout stream. Patterns of nutrient flux have also been influenced in predictable ways. This stream invader has resulted in strong top-down control of community structure and ecosystem functioning via its effects on individual behavior and population distribution and abundance.

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EFFICACY OF LARGE-SCALE QUESTIONNAIRE APPROACHES TO UNDERSTANDING RECOVERY PLANS.

The SCB, with NCEAS, created an ambitious project to analyze the science in recovery plans for endangered species using a questionnaire-based survey. That study involved 19 universities and hundreds of graduate students coordinated to review nearly two hundred recovery plans. The project involved querying recovery plans using thousands of questions. The UNR group used the dataset from the SCB project to address the hypothesis that a “university effect” would preclude an efficacious analysis of recovery plans. We used three approaches to assess the possibility of a university effect, and all approaches indicate that a small proportion of questions in the SCB questionnaire could be answered consistently among universities. A neural network analysis showed that a university effect existed when all questions in the questionnaire were used, whereas the adverse effect disappeared when the small proportion of unambiguous questions were used. However, the unambiguous set of questions includes questions that are generally not helpful in analyzing recovery plans. We also explored a new method of for analyzing recovery plans. That analysis showed that recovery plans sorted out according to the natural history of species. The resulting affinities among recovery plans should be the basis for a taxonomy of listed species.

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FACTORS RELATED TO LOW REPRODUCTIVE RATE OF THE SOUTH CHINA TIGER CAPTIVE POPULATION

Until recently, little was known about the South China tiger (*Panthera tigris amoyensis*), one of the world’s rarest mammals with 0-20 individuals estimated in the wild and 55 individuals in captivity in China. Pedigree analysis of the captive population indicates no net population growth since 1983 and a gradual decline in gene diversity. A reproductive evaluation of each adult and breeding pair was made to determine the relative contribution of various biological and management factors to population suppression. Problems were found at each reproductive phase: limited breeding opportunities; behavioral incompatibility/sexual apathy; low fertility; small litter size; and increased neonatal mortality. Potentially contributing factors include a skewed age/sex structure, limited zoo space, poor health/nutrition, husbandry practices, rearing history and inbreeding. Inbreeding levels calculated from pedigree information assuming unrelated wild-caught founders show no significant relationship with sperm parameters, litter size, sex ratio or neonatal mortality. Inbreeding effects may be confounded with other factors such as nutrition; alternatively, founders may have been related. Alternative founder relationships were modeled and examined for inbreeding effects. Study results suggest that no single factor is responsible for low reproduction. Efforts to improve reproduction need to be multi-faceted and should include recommended modifications in husbandry and genetic management.

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## TESTING PREDICTIVE MODELS OF THE DISTRIBUTIONS OF THREATENED LARGE FAUNA AT KHAO YAI NATIONAL PARK, THAILAND.

In order to effectively manage large mammals and birds that are targets for hunting, it is first necessary to know and predict their distributions in reserves. In this study the spatial distributions of six groups of threatened wildlife species and their core areas at Khao Yai National Park were estimated using a universal kriging method and GIS to interpolate sampled abundance data collected during 1995. The spatial models generated by this process were compared with survey data using camera-traps in 1999-2000. The camera-trap data fit the models for gaur (*Bos gaurus*) and sambar (*Cervus unicolor*) suggesting that these species distributions are relatively stable over time scales. Models for elephants (*Elephas maximus*) and bears (*Helarctos* and *Selenarctos* spp.) were less predictable due to more human influences or other temporal factors. Models for gibbons (*Hylobates* spp.) and hornbills (Bucerotidae) agreed with distribution maps generated from direct observations recorded by experts. Using this information along with knowledge of patterns of human use it is possible to formulate and direct specific management activities to reduce wildlife poaching in the park.

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## POPULATION GENETICS AND COLONY STRUCTURE OF THE INVASIVE ARGENTINE ANT IN ITS NATIVE AND INTRODUCED RANGES.

The Argentine ant (*Linepithema humile*) is a widespread and damaging invasive species. The ecological dominance of the Argentine ant in its introduced range is largely a result of its unicolonial social organization, in which cooperative networks of nests form spatially vast supercolonies. The absence of intraspecific aggression within these supercolonies allows Argentine ants to achieve high population densities and dominate native taxa via numerical superiority. Argentine ants are neither unicolonial nor ecologically dominant in their native South American range. Population genetic analysis using microsatellite markers has shown that aggression between colonies in both ranges decreases with increasing genetic similarity. Introduced populations possess low levels of genetic diversity and high levels of genetic similarity as a consequence of a population bottleneck, and the change in colony structure appears to be a consequence of this change in the underlying genetic relationships. Moreover, the use of genetic cues for recognition coupled with the large size of supercolonies creates an opportunity for positive frequency-dependant selection to operate in the introduced range, further reducing genetic diversity and promoting greater unicoloniality. Because many other invasive ants are also unicolonial, the loss of genetic diversity during introduction may be a common phenomenon leading their success as invaders.

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## COWBIRD DISTRIBUTION AND PARASITISM AT A GEOGRAPHIC RANGE EDGE.

Many songbird populations may be declining because of exposure to brood parasitism as brown-headed cowbird populations expand across North America. Songbirds in fragmented forests and structurally simple habitats such as grasslands are often particularly susceptible to cowbirds. We measured cowbird abundance and parasitism of songbird nests in longleaf pine/wiregrass ecosystems in southern Alabama and northwest Florida where brown-headed cowbirds have only recently invaded. Abundances were low (average of one per 20 point count locations) with most detections being of single males. Only one of 150 songbirds nests was parasitized. The parasitized nest and all cowbirds detected were along forest edges near pastures. No cowbirds were detected more than 250 meters from an edge despite the extremely open aspect of the forest structure. We suggest that the low regional cowbird population size is an explanation for the paucity of cowbirds in the longleaf forests. However, because longleaf pine forests are essentially grasslands with scattered perches (pine trees) cowbirds can use to locate nests, the longleaf pine bird communities may be extremely susceptible to brood parasites if populations of cowbirds continue to increase.

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## PATCHY DISTRIBUTIONS AND POPULATION PERSISTENCE: PYGMY RABBITS IN THE GREAT BASIN

Although only about 10% of the land area occupied by sagebrush communities in the Great Basin has been converted to intensive use (chiefly urbanization and irrigated agriculture), past livestock grazing practices, fire control, range "improvement" projects, and the invasion of alien weeds have resulted in the conversion of considerable acreage of vegetation once co-dominated by sagebrush and native bunchgrasses into dense, monotypic stands of sagebrush or into pure stands of alien weeds. Of the many sagebrush-dependent species in the Great Basin, the pygmy rabbit

(*Brachylagus idahoensis*) is the least understood and the most vulnerable. The pygmy rabbit is totally dependent on big sagebrush growing on deep, friable soils for year-round habitat, and it has poor dispersal abilities. Most optimal habitat occurs in valley bottoms, and these locations have been the primary foci of urbanization and conversion to irrigated agriculture. Thus, the pygmy rabbit is particularly vulnerable to additional habitat loss and fragmentation. We sought to detect pygmy rabbit persistence by visiting sites from historic records in the state of Nevada during summer 2000 and found occupation in <10% of those sites. We discuss the implications of habitat fragmentation on the already patchily distributed pygmy rabbit and its influence on persistence.

TUNISON, J. TIMOTHY, and Stephen J. Anderson. Hawai'i Volcanoes National Park, P.O. Box 52, Hawai'i National Park, HI 96718, USA (JTT) and Haleakala National Park P.O. Box 269, Makawao, HI 96768, USA (SJA). MAINTAINING AND RESTORING NATIVE ECOSYSTEMS IN HAWAII'S NATIONAL PARKS.

Alien species have altered the composition and function of native ecosystems in Hawai'i. Typically ecosystems below 1,200 m in elevation are highly altered. National Parks in Hawai'i have begun active management to maintain, restore, or rehabilitate native communities and ecosystems. Restoration strategies in the parks emphasize natural recovery following the removal of keystone alien species. The first priority of park restoration programs is the control of introduced feral goats, feral pigs, mouflon sheep, and axis deer through fencing and hunting, snaring, and trapping programs. Control of key alien plant species that displace native vegetation is then undertaken. Strategies include control of recently established invasive species, inside and outside of parks, control of widespread species in the most intact and biologically diverse areas of the parks, and support of biocontrol research. Restoration methods have largely been successful in selected areas and are now being attempted at a larger scale in the parks and adjacent conservation lands. Research has begun to develop control techniques for introduced Argentine ants, yellow jacket wasps, rats and other species with wide-ranging impacts on native communities. Parks are now beginning to rehabilitate highly altered ecosystems, typically with outplanting and seeding to achieve replacement native or near-native communities.

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LANDSCAPE ANALYSIS AND SURVEY OF RARE CALCAREOUS GLADE "ISLANDS" IN FORESTED EAST TEXAS.

A rare herbaceous plant community and two endemic plants occur on outcrops of the Eocene-aged Weches geologic formation in central east Texas. A combination of rocky, calcareous soils, seasonal drought, and periodic fires results in islands of prairie-like glades within a matrix of mixed pine-hardwood forest. Because of habitat loss and threats to remaining populations, a critical need exists for identifying new occurrences of this rare plant community. The seven known occurrences are all on private land in a highly fragmented landscape, and accessing land for biological surveys is often difficult. The purpose of this project was to identify new sites that may contain examples of the Weches glade community. We identified 48 potential sites by analyzing aerial photography, surface geology, and soil data in a geographic information system. We then researched the land ownership of the sites, contacted landowners, and determined the condition of the sites through ground-truthing, resulting in 13 sites with good habitat potential. Biological surveys of these sites will add to knowledge about the status and distribution of Weches glades on the landscape, and relationships developed with landowners may provide opportunities to restore and protect examples of this rare plant community.

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PLANT/POLLINATOR SYNDROMES: A SYNTHESIS FOR THREATENED AND ENDANGERED PLANTS OF THE U. S.

The U.S. Fish and Wildlife Service list more than 700 plant species as threatened or endangered. Of these species the absolute cause for their population decline is known for only a few. The disruption of plant/pollinator mutualisms may be a contributing factor in some cases. Previous studies estimate that 8.3% of the world's angiosperms are pollinated by wind while most of the remaining flowering plants are animal pollinated. Beetles (coleoptera) contribute to the pollination of a majority of angiosperms (88% world wide). Hymenoptera, lepidoptera and diptera also commonly participate in pollination mutualisms. Reduced abundances pollinators or changes in plant distributions or habitat, which in turn may decrease the likelihood of the pollinator encountering the plant species, may cause disruption of

these mutualisms. The current research synthesizes available information on plant/pollinator syndromes of the U. S. threatened and endangered species compared with the plant/pollinator syndromes of angiosperms in general.

TURTON, STEPHEN M., and Susan L. Siegenthaler. Cooperative Research Centre for Tropical Rainforest Ecology and Management, School of Tropical Environment Studies and Geography, James Cook University, P.O. Box 6811, Cairns, Qld 4870, Australia.

#### EFFECTS OF ROADS AND POWERLINE CLEARINGS ON VEGETATION AND MICROCLIMATE IN AUSTRALIAN WET TROPICAL RAINFOREST.

Altered microclimate regimes associated with roads and powerline clearings through forests result in edge vegetation structure and composition differing greatly from the forest interior. Degree of microclimate 'edge effects' and penetration distances should vary with linear clearing size, powerline clearings and wide roads experiencing the largest effects. Microclimate variables (air and soil temperatures, vapor pressure deficit, photosynthetically active radiation, wind), were measured and vegetation structure and composition surveyed for three linear clearing types in an area of continuous wet tropical forest: 1) roads with canopy closure; 2) roads with open canopy; and 3) powerline clearings. Numbers of 'disturbance species' (weeds, vines and pioneers) were greatest at powerline clearing edges, while rainforest species number was greatest at closed canopy edges. Absolute weed abundances were greatest at powerline clearing edges, weeds penetrating less than 20 m and all disturbance species decreasing from edge to forest interior. Microclimate alterations generally did not penetrate more than 30 m for all three treatments, the powerline clearing exhibiting the most profound effect between 0 and 12 m from the edge for all variables. Roads traversing rainforest tracts should be kept narrow to allow retention of canopy above them, consequently maintaining forest processes and reducing weed invasions.

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#### BEHAVIOR OF A REINTRODUCED POPULATION OF CAPTIVE BRED CRITICALLY ENDANGERED PUAIOHI.

The population of Puaiohi (*Myadestes palmeri*), a thrush endemic to the island of Kaua'i, is estimated to consist of 200-300 individuals, the majority of which are concentrated in a single drainage in the Alakai Wilderness Preserve. Current recovery efforts are focused on expanding the limited range of the species by reestablishing a population in a separate drainage where they had historically been known to exist. Thirty-four captive-bred Puaiohi were fitted with radio transmitters and released by The Peregrine Fund (currently Zoological Society of San Diego) into the Alakai swamp from 1999-2001. In 1999 there was 100% survivorship of all birds up to 9 weeks after release (transmitter life). Released birds dispersed into at least four different drainages in the preserve, and females established breeding territories from 0.3 - 3.9 km from the release sites. Captive-captive and captive-wild pairings were confirmed and recruited successful nestlings. The presence of Puaiohi in the Kawaikoi drainage, has also attracted more wild birds into the area. Although the ultimate measure of the success of the reintroduction will be the establishment of a self-sustaining breeding population of Puaiohi in the Kawaikoi drainage, current efforts look promising.

UNABIA, CATHERINE R. C. Kewalo Marine Laboratory, University of Hawai'i, 41 Ahui St. Honolulu, HI 96813, USA.

#### DISCOVERY OF AN ALIEN SEAGRASS IN HAWAII: POTENTIAL IMPACTS AND CONTROL ISSUES.

Only one seagrass, endemic *Halophila hawaiiiana*, is reported from Hawai'i. Pantropical *Halophila decipiens* was recently found at two widely separate locations: close to the Kahala Mandarin Hotel (KMH) on south O'ahu Island, and Kāne'iohe Bay on eastern O'ahu. Possible vectors between the two locations are under investigation. Surveys of other areas on O'ahu as well as other islands are underway. The capacity for reproduction and dispersal appears much higher in the alien seagrass, as each plant bears both male and female flowers and sets 25 to 30 tiny, buoyant seeds at each leaf node, while the native has plants of separate sex, only occasionally flowers, and rarely produces seeds. The endemic species has been replaced by the alien in approximately 2/3 of the area formerly occupied at the KMH site. A small endemic gastropod lives only on the endemic seagrass, grazing its leaf tissue. In laboratory trials, adult snails collected from *H. hawaiiiana* do not graze the hairy-leaved and spiny-edged *H. decipiens*. However, limited grazing damage found on the alien suggests that in the field some snails will accept this food. A pilot project to control the effects of the alien seagrass and limit its spread is being designed.

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#### TERRESTRIAL CUBAN BIODIVERSITY AND ITS CONSERVATION STATE: A TOOL FOR SUSTAINABLE DEVELOPMENT IN CUBA.

Conservation of biodiversity is a concept that includes its protection and rational use, and is fundamental in achieving ecological stability, raising the standard of living of the population and maintaining the bases for the sustainable development of our country. To achieve this, Cuba designed the National Strategy for the Conservation of Biological Diversity that includes national-level research and action plans. Cuba harbors the highest biological diversity and degree of endemism in the Antilles, establishing the country as a site of regional and world heritage value. The National Study of Biological Diversity categorizes 42 types of ecosystems and 23 high and medium level landscape types which are related to the high species diversity. 6,500 species of vascular plants (51.4 % are endemic), and more than 19,600 species of animals are known. However, it is estimated that only 50% of the animal species in the country have been described, being invertebrates (with 42% endemism) the least-studied group. The National Strategy states that "...the objectives of sustainable use and conservation of biological diversity ... should be integrated to territorial and sectorial policies..." and establishes 11 goals, 56 objectives and 142 actions, of which approximately 16% are in the implementation phase.

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#### NO ONE IS AN ISLAND – COLLABORATING FOR CONSERVATION ACROSS BOUNDARIES.

A new potential conservation tool for the 21<sup>st</sup> Century is currently emerging. Increasingly conservation organizations and the donor community are shifting their interest from single-site level conservation approaches towards landscape level approaches. Acknowledging that international borders are political and not ecological boundaries, conservation approaches require insight into Transboundary Natural Resource Management. However, experiences in this field are limited. This presentation will address the lessons learned by the Biodiversity Support Program from analysis of six case studies, four regional overviews and exchanges with numerous experts in sub-Saharan Africa. The study, undertaken in collaboration with many other conservation organizations and experts, has highlighted key questions to address before starting transboundary activities as well as during implementation. Issues include levels of operation, type of activities and facilitation of the process. Constraints and opportunities identified will be shared to promote more effective transboundary approaches. Finally, the case will be made that it is more effective to treat Transboundary Natural Resource Management as a process, with a mixed toolbox, rather than a fixed approach or goal.

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#### RESTORING TOP CARNIVORES AND FISHERIES: THE ECOLOGICAL NAÏVETÉ OF MULTI-PURPOSE MARINE RESERVES,

Marine reserves may be intended to restore marine ecosystems, including recovered populations of top carnivores, and to protect harvested species to avoid collapse of fisheries. However, top carnivores may reduce fishery productivity. Thus, restored ecosystems may be incompatible with increased fishery productivity in multi-purpose reserves. We empirically evaluate this hypothesis using sea otters and red abalones in California. Sea otters are top carnivores in coastal ecosystems, are beneficiaries of reserves, and are efficient abalone predators. Reserves also are one technique for restoring depleted abalone populations. We collected demographic data for red abalones at nine sites. Three were open to recreational abalone harvest and lacked sea otters. Others were within marine reserves. Four of the six reserve sites were occupied by sea otters. Red abalones were more abundant in reserves lacking sea otters compared to locations lacking sea otters but subject to harvest, and to locations with sea otters. We conclude that marine protected areas along the California coast cannot contribute to abalone fishery sustainability if, in the interest of ecosystem restoration, they also contain sea otters. Resolution could involve two categories of spatially segregated single-use marine reserves, one focusing on ecosystem restoration and the other on fishery development.

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THE MYTH OF THE SUSTAINABLE LIFESTYLE.

Lately "sustainability" is frequently discussed, but never adequately defined. I will place it on a firm foundation and at the same time, show why it is inherently unattainable. However, once precisely defined, it provides a clear guide to action "in the right direction". "Sustainable" means "indefinitely repeatable, without harm". The last two words are the most important. Example: genetic diversity is one of our highest values. Destruction of unique genetic resources is thus a "harm". We need to kill to eat, and yet all killing of reproducing organisms, even of a single individual, risks destroying unique genetic biodiversity: new genes are created by mutation, which initially happens in a single individual; killing such an individual could destroy a valuable gene. Thus sustainability is a worthy goal, but not one that is actually attainable. The best that we can do is to attempt to minimize harm. Calling everything we currently like "sustainable" prevents real progress. Another example: all organisms produce wastes that, in sufficient quantities, are incompatible with their own existence. Thus, none of them can be said, by themselves, to live sustainably. Because of their obvious finiteness, islands are the perfect laboratory for studying sustainability.

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#### THE GENETIC IMPACTS OF HABITAT FRAGMENTATION: LESSONS FROM HAWAIIAN KIPUKA.

Habitat fragmentation may impact the genetic structure of remnant populations by limiting gene flow. However, genetic consequences of fragmentation can be difficult to assess when fragmentation is too recent for measurable genetic changes to have accumulated. Qualitative and quantitative information about long-term genetic impacts can be determined by utilizing older, naturally-fragmented systems, by comparing species with different ranges or dispersal abilities, and by comparing molecular markers with different rates of mutation or effective population sizes. We investigated the genetic structure of three species of Hawaiian *Tetragnatha* spiders in small forest fragments surrounded by a 150 year old lava flow on the island of Hawai'i. Ongoing work has revealed substantial among-species variation in population size and habitat specialization for *T. quasimodo* (abundant and cosmopolitan), *T. anuenue* (abundant and restricted) and *T. brevignatha* (rare and restricted). To separate historical from contemporary levels of gene flow and to estimate the effects of habitat fragmentation on population subdivision in this system, we examined genetic variation in each species from (1) allozymes and (2) 450 - 600 bp of mitochondrial COI. Results suggest that population differentiation increases with increased habitat restriction, but only for forest specialist species, supporting the hypothesis that habitat fragmentation disrupts gene flow.

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#### A PREVENTION PLAN FOR THE RED IMPORTED FIRE ANT (*Solenopsis invicta*): A SEVERE AND IMMINENT THREAT TO HAWAII.

Hawai'i faces imminent invasion by the red imported fire ant (*Solenopsis invicta*), a notoriously destructive and aggressive stinging ant that is highly invasive, impossible to eradicate once established, and poses a serious threat to biodiversity. Recently established in California, the risk of this ant becoming established in Hawai'i is very high, due to the huge quantities of goods shipped to Hawai'i from California. The objective of this project is to take a proactive approach in protecting Hawai'i's native ecosystems from invasion by this ant by developing a red imported fire ant (RIFA) prevention plan for the State of Hawai'i. Actions identified as necessary for preventing establishment of RIFA in Hawai'i are presented. Actions fall within three major groups: 1) determination of pathways through which RIFA are transported and development of strategies for preventing them from reaching Hawai'i; 2) development of strategies for detecting RIFA quickly should they get to our shores; and 3) establishment of methods with which to deal with incipient populations before they become firmly established. As indicated by the actions presented, a successful prevention plan will require immense cooperation among many sectors, both public and private.

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#### INVESTIGATING ARBUSCULAR MYCORRHIZAL FUNGI AS A CONSERVATION STRATEGY IN AGRICULTURE.

Large-scale agricultural production often utilizes monoculture cropping systems that decrease biodiversity and exacerbate erosion and pest problems. Agricultural systems in this regard can be considered degraded and require restoration to improve the integrity of the natural components of farms. AMF have been shown to play an important role in determining plant community composition (e.g. crop plants and weeds), implying that plant diversity can be affected by the presence or absence of AMF in a system. It has been shown that there are definite AMF host and non-

host weed species. Maize biomass has been shown to increase when non-host weeds are eliminated from a system, and decrease when host weeds are eliminated. Our preliminary data showed a biomass increase in host weeds in the presence of AMF, and a significant inhibition of non-host weeds in the presence of AMF. This suggests using AMF as an ecologically based biocontrol aimed at non-host weed species. Agricultural practices that favor AMF will be proposed as a means to direct weeds to decrease their negative effects and increase their beneficial attributes. These practices will provide further environmental benefits and an increase in biodiversity within the agroecosystem.

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#### ARE ECOLOGICAL SPECIALISTS MORE SUSCEPTIBLE TO DISTURBANCE THAN GENERALISTS?

Niche breadth has been hypothesized to be associated with species' response to disturbance. Disturbance is usually believed to negatively affect specialists, while it is usually believed that generalists tend to be benefited by disturbance; we call this the "specialization–disturbance" hypothesis. We also propose an associated hypothesis (the "specialization–asymmetry–disturbance" hypothesis), under which both specialization and symmetry of interactions would explain species' responses to disturbance. We test these hypotheses using our data from a plant–pollinator system that has been subject to cattle grazing (i.e., a biological disturbance) in southern Argentina. We developed indices to quantify interaction specialization, specialization of interaction partners (used to quantify symmetry of interactions), and species response to disturbance. We found no relationship between degree of specialization and species response to disturbance. We also found that plant–pollinator interactions tend to be highly asymmetric in this system: there was no relationship between the degree of specialization of a given species and the degree of specialization of its interaction partners. However, asymmetry of interactions did not explain the variability in species' response to disturbance. Thus, both hypotheses are rejected by our data. We discuss several factors that can explain the lack of association among these variables.

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#### LARGE-SCALE, INTEGRATED MANAGEMENT OF AN INVASIVE SPECIES: THE BROWN TREESNAKE ON GUAM.

The introduced brown treesnake (*Boiga irregularis*; BTS) has extirpated most of the native terrestrial vertebrates on the island of Guam, caused millions of dollars in power-outage related damages, impacted the island's poultry industry, and is responsible for numerous bites on infants. BTS control efforts, using specially-designed snake traps, snake detector dogs, night-time hand capture, and snake-proof barriers, have primarily focused on the prevention of inadvertent snake dispersal from Guam. More recently, federal and local agencies have initiated snake removal across blocks of native forest in support of native wildlife recovery efforts and electrical resource protection. The lack of landscape-scale control tools limits the scope of control work to relatively discrete (less than 25 ha) locations; although current control programs are successful, an island-wide BTS control effort would be cost and labor prohibitive. Continued refinements in available technology, such as the development of an artificial snake attractant for use in traps and toxicant delivery stations, and the development of new control methods, such as oral toxicants, will facilitate expanded control efforts and increased programmatic efficacy.

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#### AQUATIC CONSERVATION IN CALIFORNIA COASTAL WATERSHEDS: GEOSPATIAL INFORMATION AS A STARTING POINT.

Most of California's north coastal watersheds are listed as impaired under the federal Clean Water Act. Additionally, all of these watersheds are within Evolutionarily Significant Units for two federally Threatened species of anadromous salmonids. Here we focus on the Navarro River watershed to examine aquatic conservation strategies for coho salmon (*Oncorhynchus kisutch*). We have identified a 78.4 percent reduction in the linear distribution of coho salmon from their historic watershed distribution over the last 12 years. Through the use of classified Landsat imagery and high-resolution digital elevation data, a geospatial stream-shading model was developed to fulfill portions of the Total Maximum Daily Load determinations for temperature. In turn, this shading model with variables of current shading condition and potential shading condition significantly predicts the presence or absence of coho in historically

inhabited reaches within the watershed. We developed a comprehensive GIS, which incorporates the spatially explicit shading model, to identify: key watersheds for conservation, key migratory corridors, and zones of rehabilitation. These key components provide the basis for an aquatic conservation strategy that can be applied to other watersheds using the same readily available data.

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#### FIELD ECOLOGICAL STUDY OF THE MARQUESAN IMPERIAL-PIGEON (*DUCULA GALEATA*) FOR CONSERVATION PURPOSE.

The Marquesan Imperial-pigeon or Upe (*Ducula galeata*) is a critically endangered species, surviving on Nuku Hiva, (French Polynesia). In June 2000, 5 birds were translocated onto Ua Huka at a distance of 44 km. However, most of the bio-ecological traits of the Upe are still almost unknown. Decisions on successful conservation measures are neither clearly justified nor reliable. Between April and September 2000, an intensive field study was performed on Nuku Hiva aiming to clarify Upe's bio-ecological traits. The survey of all inhabited sites and the total of observed birds allowed us to estimate the actual population between 100 and 140 individuals. Even if this fruit-eating species moves frequently around to search for food, its living quarter is restricted to the main volcano ridge, in particular the forest patches of some remote valley bottom and high cliffs, within a 10 km radius. Most of the tree species used for feeding and nesting are identified. It is now also possible to differentiate in the field between young individuals and adults. Consequently, population structure and dynamics models built on this set of preliminary field data are tested to evaluate the long term survival potential of this rare insular species.

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#### WHY IS IT IMPORTANT TO SUSTAIN HAWAIIAN ECOSYSTEMS?

The Hawaiian Islands are a model system for many evolutionary, ecological, and conservation studies. The evolutionary radiation of plant and animal species in Hawai'i makes the islands a natural laboratory for understanding speciation and subtleties of organism-environment interaction, and the vulnerability of many products of evolution in isolation to human-caused change makes Hawai'i a testing ground for working with species on the edge of extinction. I suggest that the ecosystems of Hawai'i represent a model system for understanding the regulation of ecosystem structure and functioning. The geology and isolation of the islands provide a nearly constant background, against which the effects of spectacular variation in climate and soil age can be evaluated with a precision that is unmatched elsewhere. Conserving and sustaining Hawaiian ecosystems supports resources that are valuable in their own right — and that can teach us how the world works, and contribute to the maintenance of threatened Hawaiian plants and animals.

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#### PRIMATE CONSERVATION IN AN AFRICAN RAINFOREST FRAGMENT.

The Kakamega Forest in Western Kenya has experienced rapid deforestation. Its complete loss will occur in 2031 if clearing continues at its historical rate. Areas of the forest that have not been cleared have been steadily degraded resulting in species declines and losses even in intact forest. Groups of black and white colobus monkeys, or guerezas (*Colobus guereza*), in a forest study site were found to decline from 18 groups in 1992 to 12 groups in 1998. This decline is particularly worrisome because it took place in an area of forest that has not decreased in size and because guerezas are among the least sensitive primates to forest degradation. Forest degradation is a conservation issue that is understudied because it is far subtler in pace and effect than deforestation. Five other primate species live in the Kakamega Forest and nearby forest fragments. A decline in guerezas suggests that even bigger declines might be occurring in these species, two of which are threatened with extinction in Kenya (*Perodicticus potto* and *Cercopithecus neglectus*). These species may be part of the primate "extinction debt" in Africa, with their extinction expected based on past deforestation even if the remaining forests are left intact.

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#### BENEFITS OF MATE CHOICE IN CAPTIVE BREEDING PROTOCOLS.

Captive breeding programs are critical for the preservation of endangered species, and have had their foundations in population genetics theory. The 'mean kinship' breeding protocol is highly recommended and utilized, and guides the 'artificial pairing' of animals for the purpose of retaining maximal genetic diversity. In contrast, a behavioral-ecology

perspective suggests that a protocol allowing ‘mate choice’ could improve the short- and long-term viability of captive populations in at least three major ways. First, females reap fitness benefits for their offspring through mate choice for either “good genes” or “compatible genes”. Second, expression of mate choice allows for the preservation of natural mating behavior and thus increased success in reintroduction. Third, these benefits do not necessarily come at the cost of genetic management, since mate choice is a known mechanism for the maintenance of genetic variability. We also discuss our current experiment (using guppies, *Poecilia reticulata*) designed to quantify the fitness, genetic, and behavioral benefits of mate choice *versus* mean kinship.

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#### EXAMINING LONG-TERM SURVIVAL AND MOVEMENT PATTERNS OF HORSESHOE CRABS.

Due to their economic, ecological, and medical importance, information on the life history of horseshoe crabs has become essential in order to develop effective management strategies. As the horseshoe crab fishery has drastically increased, there has been increasing concern that their population levels could be in decline. While several studies have examined short term survival of horseshoe crabs bred in the biomedical industry, estimates of long-term survival and movement patterns of bred crabs following release are necessary. During the summers of 1999 and 2000, a total of 5,000 bred horseshoe crabs were tagged and released off the coasts of Ocean City, Maryland and Chincoteague, Virginia. Prior to release, demographic information was recorded for each tagged crab. Of the 5,000 tagged crabs, there have been 56 re-sighted crabs or tags, constituting a 1.1% recovery rate. While many crabs have been re-sighted in areas close to the point of their release, some crabs have been re-sighted as far south as Virginia Beach, Virginia and as far north as Barnegat Light, New Jersey. We will also discuss needed improvements to the tagging program.

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#### WHAT HAPPENS TO FRUITS IN THE EMPTY FOREST? CONSEQUENCES OF SEED DISPERSER LOSS IN A CENTRAL AFRICAN RAIN FOREST.

In many Central African rain forests, populations of seed-dispersing primates that were already stressed by shrinking habitats have been further reduced or extirpated by commercial and/or subsistence hunting. We explore the consequences to seed dispersal of these losses by measuring fruit removal and fruit wastage for two species of trees, *Cleistopholis glauca* (ANNONACEAE) and *Pycnanthus angolensis* (MYRISTICACEAE), at two adjacent sites in Southern Cameroon - a primary forest site with high primate diversity and biomass and a secondary forest site where virtually all primates have been extirpated. Trees of both species were watched at both sites for a total of over 1450 hours (n=27 trees). Elevated fruit traps covering 5% of the area under each tree’s canopy were used to estimate the quantity of fruit that fell under the tree and was not dispersed. In the absence of monkeys, other arboreal dispersers such as hornbills did not significantly increase their take of these fruits and a higher percentage of fruit fell under the canopy. These differences in fruit removal between primary and secondary forest will likely have profound ramifications for the seed shadows of trees in secondary forest and ultimately for the regeneration of those forests back to mature forest.

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#### CURRENT VS HISTORICAL DIVERSITY IN PACIFIC SALMON—WHAT HAVE WE LOST?

Recently completed status reviews have identified over 50 ESUs in seven species of anadromous salmonids in the Pacific Northwest, about half of which are listed as threatened or endangered species under the federal Endangered Species Act. As efforts turn toward restoration of natural salmon populations and ESUs that will be sustainable into the future, it is a good time to take stock of current levels of intraspecific diversity in the context of what existed historically. Within each species, we identified different hierarchical levels for three major axes of diversity—ecology, life history, and genetics—based on extant populations. Next, we compiled records of historical occurrence of salmon and estimated the same diversity components for populations that are now extinct. We compared current and historical patterns of diversity at the level of ESUs as well as individual populations. Considerable variation was found among species in the amount of diversity that has been lost over the past century and a half. Extinctions have been the most pervasive for sockeye salmon, but significant amounts of ecological/life history/genetic diversity have also been lost in chinook and coho salmon and steelhead. In each of these species, what may have represented historic ESUs are now extinct.

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#### DRAMATIC EFFECTS OF RAINFALL ON SPECIES DISTRIBUTIONS IN THE SANTA MARGARITA RIVER.

The Santa Margarita River is one of the largest and least impounded coastal watersheds remaining in southern California. Large segments of the river are in relatively undeveloped private and public holdings that have insulated the drainage against many of the effects of urbanization. Despite these conditions, only one of the four freshwater fish species native to the river still inhabits the system, the arroyo chub, (*Gila orcutti*). During three years of fieldwork (1997, 1998, 1999) 131 sites were sampled, 13 of which were sampled every year. Of the 18 species detected at the estuary three were exotic. Of 11 species detected in the river only two were native. We found that yearly variation in native and exotic species distributions in the river was strongly influenced by rainfall. In the 1998 field season, during an El Nino weather event, the arroyo chub became more abundant throughout the system, while the distribution and density of some exotic species were negatively impacted. This data indicates that recovery of native species in the system may be linked to natural hydrologic processes as long as there are available refugia for the natives to colonize from.

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#### POPULATION DYNAMICS OF ENDANGERED WILD AND REINTRODUCED SAN CLEMENTE LOGGERHEAD SHRIKES.

The San Clemente Loggerhead Shrike (SCLS) is a critically endangered bird with fewer than 20 wild individuals on San Clemente Island, California. In this talk, we will discuss recent reintroduction efforts and compare population dynamics of wild vs. reintroduced SCLS. In 1999 and 2000, reintroductions of captive bred SCLS were attempted using four release techniques combined with supplemental feeding and predator control. A total of 74 birds have been released (1999 = 33 birds, 2000 = 41 birds). In the past two years, overwinter survivorship of juvenile release birds was higher than adult released birds, opposite of what is seen in wild birds. For the first time, we documented a captive bred bird surviving a winter in the wild to successfully fledge young the next year. Breeding success of SCLS in the wild averages around 41%. Depredation is the most important cause of shrike mortality (wild and released) with feral cats, introduced rats, native foxes, Common Ravens, and raptors being the most important sources of mortality. The recovery of the critically endangered San Clemente Loggerhead Shrike will rely on continued progress and success in reintroducing captive bred birds in ways that promote successful recruitment into the wild population.

WARSHAUER, FREDERICK, and James Jacobi. USGS, Pacific Islands Ecosystem Research Center, P.O. Box 44, Hawai'i National Park, HI 96718, USA.

#### SURVEY OF AND CONSERVATION PROSPECTS FOR HAWAII'I AND O'YAHU STRAND VEGETATION COMMUNITIES.

Limited attention has been given to the conservation of Hawai'i lowland ecosystems, and in particular to the coastal strand communities. Cumulative impacts from 1500 years of human lowland occupation have left only scattered, degraded remnants of this original biota. Of all the disappearing lowland vegetation, the strand has been the most limited in original distribution, but it can have the best prospects for long-term preservation. While stressful shoreline conditions limit the breadth and total distributional area of the strand communities, they also act to restrain the invasion of this habitat by alien species. The native plants surviving in the stand tend to be resilient, and the structure and composition of strand communities lend themselves much better to restoration or even reconstruction than do more upland communities. This is fortunate, as the strand is fast disappearing from the islands, and more extensive and restorative conservation efforts are much needed. Basic descriptive and biogeographic information is essential to spur and to make the most efficient use of any conservation opportunities and funding. This project has begun to rectify the informational shortfall. As opportunities have arisen, the collected information has been integrated into and instigated conservation actions with other partners.

WASSENAAR, THEO. D., Sam M. Ferreir, and Rudi J. van Aarde. Conservation Ecology Research Unit, University of Pretoria, Pretoria, 0002, South Africa (TDW and RJVA) and Department of Conservation, Auckland, New Zealand (SMF).

#### CONVERGENT DEVELOPMENT OF COASTAL DUNE FORESTS IN SOUTH AFRICA.

Restoration of disturbed landscapes may recapture lost biological diversity on a local scale, and may thus be considered a conservation action. We assess convergence of developing dune forest towards benchmark values for eight taxa in northeastern South Africa. Our analyses are based on data from a chronosequence of developing forests ranging from 1 to 21 years old and a 65+ year old undisturbed site in the same landscape. For each of the taxa we calculated three distance indices (DI's). We expected a logarithmic decay towards the mean benchmark DI. Our definition of a benchmark implies a point equilibrium state where communities are similar in all aspects of species composition. Only three groups fitted the logarithmic decay model for all DI's. Best-fit models for most groups predicted convergence within 100 years. One group was predicted to converge only in terms of species identities. If the possibility of boundary attractors at the point SE of benchmark is taken into account, only 4 groups were predicted to converge. From the analyses we conclude that landscape restoration has a limited contribution to make to the conservation of local biodiversity, particularly when considering the time required for total convergence of communities disturbed through human-altered landscapes.

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#### HABITAT RESTORATION FOR SALMONIDS: CONSIDERING ALTERNATIVE REPRODUCTIVE PHENOTYPES.

Coho salmon (*Oncorhynchus kisutch*) are native to small coastal streams marked by habitat variability. Previous workers have observed that different creek habitats (riffles and pools) are occupied by different juvenile phenotypes. Additionally, coho salmon exhibit alternative (early and late maturing) male reproductive phenotypes. We predict that different juvenile rearing habitats will produce different frequencies of adult male phenotypes. To evaluate this possibility, we reared individually PIT tagged juvenile coho salmon in two different "habitats": 1) structurally complex/hydraulically simple, and 2) structurally simple/hydraulically complex. We determined the degree of complexity of each environmental parameter by calculating the variance of multiple measurements across each "habitat". Fish were weighed and measured regularly during the freshwater growth phase before being moved to a single seawater enclosure. Our results show that phenotypic variance of juveniles, based on length and weight measurements, was higher in the hydraulically complex rearing environments than in the structurally complex environments. Additionally, the frequency of early maturing males was higher in the hydraulically complex treatments than in the structurally complex treatments (14.3% and 20% in each of two replicates compared to 0% and 5.6%). These results indicate that habitat restoration efforts for salmonids should consider population consequences of shifting male-type frequencies.

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#### ADAPTIVE GENETIC VARIATION AND UNITS OF CONSERVATION.

Evolutionarily significant units (ESUs) and management units (MUs) are discrete units of conservation that emphasize reproductive isolation over long and short evolutionary time periods, respectively. Previously, we have argued that this dichotomous summary of a continuum of population differentiation is not adequate for determining appropriate management actions (Crandall et al., 2000). We suggested an alternative approach that emphasizes the preservation of adaptive variation rather than historical isolation only. Here, I outline possible methodologies for surveying adaptive variation in nature made possible by new molecular techniques and I describe real-life examples of the approach using case studies of several species.

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#### USE OF NATURAL HERITAGE AND REMOTELY SENSED DATA TO HELP IDENTIFY A CONSERVATION NETWORK ON THE DELMARVA PENINSULA.

The Delmarva Conservation Network is a multi-state project to preserve natural land on the Delmarva peninsula (on the Atlantic seaboard of the U.S.A.) from development. As part of the planning process, we used GIS and principles of conservation biology and landscape ecology to identify a network of large contiguous blocks of natural resource lands (hubs), interconnected by corridors to allow animal and plant propagule dispersal and migration, in the hope of maintaining viable and persistent metapopulations. Biodiversity data was obtained from the natural heritage programs of the three states (Maryland, Delaware, and Virginia), and included locations of rare plants, animals, natural

communities, and other assemblages. Points of occurrence were buffered, and helped define hub locations, along with large blocks of contiguous interior forest, large wetland complexes, and natural cover with existing protected lands. An element occurrence weight, calculated from the global rarity, state rarity, and viability of the species or community, helped weight and select hubs in the network. Maps of the modeled network of hubs and corridors are being reviewed by biologists and planners, and used to help focus field investigations and conservation efforts.

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#### IMPACTS OF INTRODUCED FISHES ON AMPHIBIAN ASSEMBLAGES IN THE KLAMATH MOUNTAINS OF NORTHERN CALIFORNIA.

We examined relationships between amphibian distributions and introduced fishes in the Trinity Alps Wilderness (Klamath Mountains) of northwestern California in the summers of 1999 and 2000. These mountains support the highest diversity of amphibians in the state, with a potential of eight aquatic species in lentic habitats. Our objective was to census all water bodies that could support amphibians, fish, or both, to ascertain spatial patterns in the distributions of these taxa. With the exception of 50 water bodies in the northeastern section (Scott Mountains area) we completed this census, sampling 288 water bodies and 80% of the wilderness. We detected eight amphibian and two non-native salmonid species. Preliminary analysis indicates amphibian populations were either depressed or absent in a significant number of water bodies supporting either rainbow trout (*Oncorhynchus mykiss irideus*), eastern brook trout (*Salvelinus fontinalis*) or both. The Cascade frog (*Rana cascade*) and the long-toed salamander (*Ambystoma macrodactylum*) appear to be particularly vulnerable to population reductions or elimination due to fish predation. We discuss attributes of lentic microhabitats and metapopulation structure that have the potential to allow for co-existence of fish and amphibians at the sub-basin level in the Trinities.

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#### IMPLEMENTING A TERRESTRIAL SALAMANDER MONITORING PROJECT USING 5<sup>TH</sup> GRADERS.

Can 5<sup>th</sup> graders monitor salamander populations? Long term monitoring has been identified as a crucial element in studies of amphibian decline. Volunteer monitoring efforts may contribute to conservation by gathering needed scientific information as well as promoting greater public awareness of conservation issues. However, questions remain as to the practicality and cost effectiveness of such efforts. We conducted a two-year study to investigate the feasibility of using 5<sup>th</sup> grade residential outdoor school students to implement a terrestrial salamander monitoring project. Our intent was to assess cost effectiveness and to refine design elements necessary to ensure continuity over the duration of a long-term monitoring study. We found that it was possible to maintain a monitoring program over two years at a site in Central California. We identified potential pitfalls including insufficient funding, high personnel turnover, and relative low skill level of participants (5<sup>th</sup> graders). We argue that these obstacles can be overcome by proper study design including appropriate scaling of data, correct identification of study goals, and adequately identifying funding needs before implementation.

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#### OPTIMAL HABITAT RECONSTRUCTION FOR BIRDS IN THE MT. LOFTY RANGES, SOUTH AUSTRALIA.

We formulate the problem of optimal habitat reconstruction for avian diversity across the Mount Lofty Ranges, South Australia. The Mount Lofty Ranges is a high rainfall "island", surrounded by more arid mallee habitat. The region has suffered dramatic habitat loss and fragmentation, with only 10% of the native vegetation, primarily eucalypt woodland, remaining. Using the results of logistic regression analyses of bird species distribution across the landscape, based on historical bird atlas data as well as surveys we conducted in 2000 and 2001, we show how simulated annealing algorithms can be applied to solve the problem. The Native Vegetation Act of 1991 effectively prohibits any further clearing of native vegetation, but there is now a great exigency to restore habitat. While 8 species of birds have gone extinct in the Mount Lofty ranges historically, long extinction lag times ("extinction debt") means more species are in a perilous state. We show how to use "rules of thumb" on habitat reconstruction, such as landscape context and patch size, in order to maximize the ecological benefits given a finite amount of resources.

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#### SENSITIVITY TO DEFORESTATION INTERACTS WITH FOREST TYPE AND VARIES GEOGRAPHICALLY IN SOME NEOTROPICAL BIRDS.

Some Neotropical birds are restricted to 2<sup>nd</sup>-growth and other modified habitats in moist, equatorial regions, but require the tallest, moistest, primary forest available in drier, outer-tropical regions. From this observation, we hypothesized that degree of sensitivity to deforestation might in part be predictable from range maps, with bird species that extend into drier forests being more resistant to deforestation in the moister areas where they occur, relative to species more restricted to the latter. We tested this hypothesis using data from 88 bird species for which we had studied habitat affinities in Petén, Guatemala. For each, we determined from range maps their maximal northward distribution in the Yucatan Peninsula, which has progressively lower, drier forest toward the north. The hypothesis was vindicated; on average, species deemed tall-forest obligates near the base of the peninsula did not range as far northward into the dry peninsula, compared to species deemed forest generalists or typical of 2<sup>nd</sup>-growth. This approach may allow a crude first guess as to deforestation-sensitivity in poorly studied forest avifaunas. In addition, this pattern provides a caution that species that are resilient to deforestation in moist, equatorial forests may be sensitive to deforestation in drier sites.

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#### WATERSHED PARTNERSHIPS: A MODEL FOR LANDSCAPE SCALE BIODIVERSITY AND WATERSHED CONSERVATION.

Removing feral animals, weeds, and other threats through the combined efforts of contiguous landowners can significantly benefit both biodiversity and watershed conservation. This paper describes successful threat abatement projects undertaken by the East Maui Watershed Partnership (EMWP) and why partnerships like the EMWP could be key to sustaining biological conservation in Hawai'i. Major landowners and land managers on the windward slope of East Maui formed the EMWP in November of 1991. Although the partnership members have different mandates, priorities, and constituents, all share a common commitment to the long-term protection of the watershed. Since its formation, the EMWP has successfully constructed miles of feral animal fencing, reduced feral pig numbers, and continues to control *Miconia calvescens* thus reducing key biodiversity threats in the 100,000-acre watershed area. Due in part to the accomplishments of the EMWP, other watershed partnerships have formed on four of the Hawaiian Islands, including: West Maui Mountains Watershed Partnership (1998), Ko'olau Mountains Watershed Partnership (1999), East Moloka'i Watershed Partnership (1999), and the Lana'i Forest and Watershed Partnership (pending). These partnerships are one of our best hopes for sustaining biological conservation in Hawai'i because they greatly leverage individual landowner efforts and mitigate threats at the landscape scale.

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#### ARTIFICIAL FOOD SOURCES ALTER DISTRIBUTION AND NEGATIVELY IMPACT THE HEALTH OF AN INSULAR CANID.

Arctic foxes (*Alopex lagopus pribilofensis*) inhabiting St. Paul Island, Pribilofs, Alaska are typically distributed around the island's perimeter near natural food resources. However, recent anthropogenic changes have created artificial food sources resulting in unusually high numbers of foxes in town. Censuses of foxes were conducted prior to and following construction of a breakwater and fishery processing facility in the harbor. Numbers of foxes residing in town increased rapidly following establishment of artificial food sources (bait, by-catch, garbage). Increases in the urban fox population were attributable mainly to increased survivorship among juveniles. Tagging revealed that occasionally foxes from outlying areas also foraged in the harbor; a behavior not observed prior to breakwater completion. Concentrations of foxes may cause increased competition and aggression; urban foxes ( $n=30$ ) showed significantly higher variance in mean body weight ( $p=0.05$  males;  $p=0.006$  females) than animals residing in outlying areas ( $n=60$ ). Urban females showed higher incidence of wounds (21%) than females in outlying areas (9%). In town, foxes face elevated health risks including increased exposure to pathogens from garbage and domestic pets, and increased human persecution. Control measures aimed at foxes in town may represent an island-wide population sink for this geographically and genetically isolated carnivore.

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#### ECOLOGICAL INSIGHTS GAINED FROM A COMPARISON OF PAST AND FUTURE FIRE-CLIMATE CONDITIONS.

Understanding the historical range of variability in natural disturbances, e.g. fire, is an important consideration in conservation planning and reserve design. In most cases, the historical range is defined by the conditions of the last few centuries before Euro-American influence and based on historical and dendrochronological records. These data provide little information on the frequency of severe, stand-replacing fires. High-resolution charcoal records from lake sediments offer fire reconstructions that span several millennia and disclose the frequency of severe fires and changes in fire regime during major climate shifts. For example, charcoal records from the Pacific Northwest show that fires were more frequent than at present from 6000-10,000 yrs ago and ca. 1000 yrs ago, when the region experienced widespread droughts. These past fire-season conditions are comparable to those portrayed in model simulations of future climate, which indicate increased drought and reduced soil moisture during summer. Potential changes to the fire regime exceed those observed over the last few centuries from tree-ring and historical data. Thus, where possible, conservation strategies should consider longer time series, such as provided by lake-sediment records, in order to understand the range of climate-fire interactions that are likely to occur in the next century.

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#### THE EFFECTS OF STREAM FRAGMENTATION AND FLOW REGULATION ON IMPERILED FRESHWATER MUSSELS.

Unionid mussels are experiencing an alarming decline in diversity, abundance, and distribution. Mussels have complex life cycles that include a larval stage requiring temporary attachment to a host fish. Dams that prevent host fish migration block gene flow and prohibit recolonization of river segments. Artificial flow regimes result in decreased fitness of individuals and populations. In this study, I tested the suitability of an anadromous fish, the Atlantic salmon, *Salmo salar*, as a host for larvae of the endangered dwarf wedgemussel, *Alasmidonta heterodon*. Results indicate that juvenile salmon are very effective hosts. In addition, I used drift net sampling to determine larval release phenology of *A. heterodon* in the Ashuelot River downstream of a flood control dam. I used *in situ* monitors to record changes in flow, light intensity, and temperature. Results indicate weak or no correlation between the number of larvae collected and changes in light intensity or temperature but a strong negative correlation between extreme high flows and the number of larvae collected. Extreme episodic flooding from dams exposes larvae and juveniles to flood-induced damage, mortality, or displacement downstream to potentially unfavorable habitat. As a consequence, mussel populations may experience reduced recruitment, decreased population densities, and local extinctions.

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#### WHEN IS A SMALL PARK BIG ENOUGH? INTER- AND INTRA- ISLAND EFFECTS IN CANADA'S NATIONAL PARKS.

Research has shown that, compared with historic distributions, many of Canada's national parks have lost disturbance sensitive mammal species. Here, I use Geographic Information Systems (GIS) to analyze the landscape within and surrounding twenty-four of Canada's national parks to determine how various landscape attributes are correlated with species losses. Island biogeography predicts that small parks will tend to lose more species. The results show that there is not a clear correlation with park area and species losses. Thus, other landscape factors, such as degree of isolation from the surrounding habitat, and human development within and surrounding the parks, may be having an effect. GIS is used to identify and buffer human built structures to calculate the effective area within each park. In addition, satellite data is used to calculate the amount of different types of habitat within and surrounding a park. Results show that many of these impact variables are highly correlated with each other. Principal component analysis shows component loadings divided between in-park and outside-park variables. Components were significantly correlated with losses of disturbance-sensitive mammals. This research demonstrates that park size is only one determinant of how well protected areas will preserve historic complements of mammal species.

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#### MAKING A DIFFERENCE: LESSONS FROM A MAJOR RESEARCH PROGRAM ON REMNANT NATIVE VEGETATION.

The first phase of the national research and development program on the rehabilitation, management and conservation of remnant native vegetation focused on private land in the highly cleared regions of southern Australia. It funded over 30 ecological, socio-economic and planning projects that changed the way we think about fragmented ecosystems and their associated policy and management environments. Examples of the key findings include the contribution of small patches of vegetation and riparian areas to the maintenance of biodiversity and the need to consider the nature of the 'sea' (land-use) surrounding the 'islands' (patches of native vegetation). Potential limitations associated with the use of surrogates were also identified, which could have significant conservation implications. The role of local government and philanthropic organisations in native vegetation management is now also better understood. As importantly, the program demonstrated the importance of participatory research and effective extension/communication activities. Many challenges lay ahead and the second phase of the program has identified 'landscape design' as a priority research area. The long-term viability of fragmented systems and the integration of native vegetation management into agricultural production systems are also key issues. Understanding the social, institutional, cultural and economic context is therefore critical for managing these systems.

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#### SOLVING THE INVASIVE SPECIES PROBLEM THROUGH SCIENTIST INPUT AND ADVOCACY.

The spread of invasive species is one of the most serious global environmental changes underway, posing enormous ecological and economic costs. Scientists can play an important role in solving this problem and indeed, recent progress in invasive species policy can be attributed in large part to scientists' involvement. For example, a 1998 letter to Vice President Gore from ~500 scientists on the importance and urgency of the invasives problem was the impetus for the 1998 Executive Order establishing a National Invasives Species Council (NISC). With an administration unlikely to view environmental issues as a high priority, strengthened involvement by scientists in the policy realm is more important than ever. UCS has recently launched a new project that aims to reduce both the introduction and spread of invasives and to limit their impacts on native ecosystems and species. We have identified several ways in which scientists can educate policymakers and strengthen public understanding and policy on key issues. These include providing recommendations for action to the new administration, communicating the importance of retaining the NISC and implementing its Management Plan, and outreach to the public, media and policymakers on the seriousness of the invasives threat and some practical solutions.

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#### FACTORS INFLUENCING THE BREEDING SUCCESS OF THE BROWN-HEADED COWBIRD (*MOLOTHRUS ATER*).

Numerous studies have shown that brood parasitism by the brown-headed cowbird is an important problem for many North American bird species, especially those breeding in fragmented forests. My study investigates the reverse question: what is the effect of the host community on cowbird reproduction? I compared the number of cowbirds fledged in two habitats, a mature but fragmented forest and an old field. I measured host density by spot mapping (N=800 point counts), parasitism and nest predation rates by finding and monitoring host nests (362 nests of 25 species; 4012 nest exposure days), and female cowbird density using capture-recapture methods (N=409 trap hours and 65 captures). Preliminary analysis indicates that the forest produces almost twice as many cowbird fledglings per unit area as the old field ( $32.1 \pm 3.9$  SE vs.  $17.2 \pm 4.1$  SE); I will also estimate cowbird reproduction per capita. The most important factors influencing cowbird reproduction were nest predation probability and host density. Because cowbirds don't enter large, intact forests, reducing forest fragmentation would minimize the cowbird's access to its superior breeding habitat, and therefore reduce parasitism of all cowbird host species, not only those breeding in forests.

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#### EXAMINING THE EFFECTS OF CATCHMENTS ON THE GENETIC STRUCTURE OF LOTIC ORGANISMS AND THEIR ROLE IN DEFINING UNITS FOR CONSERVATION.

The longitudinal and hierarchical nature of lotic systems and the geological nature of catchment units create islands of aquatic habitats within an otherwise terrestrial landscape. For lotic organisms this imposes a number of barriers to dispersal. We examine the effects of catchment units on the genetic structure within populations of lotic organisms

characterised by different dispersal traits. Taxa included three winged insects; a net-winged midge (Diptera: Blephariceridae) very limited in dispersal, a stonefly (Plecoptera: Notonemouridae) an intermediate disperser and a dragonfly (Odonata: Aeshnidae) capable of wide dispersal, and a fish species, the Cape Galaxiid (Teleostei: Galaxiidae). Allozyme electrophoresis and mtDNA sequencing of the COI region were used to examine genetic structuring within and among streams in two discontinuous mountain ranges. Significant population structuring was observed. Congruence within the data and presence of two divergent clades suggests a significant vicariant event around 3-4 MYBP. Results suggest habitat discontinuity is important in limiting adult dispersal between discontinuous mountain ranges. In contrast, genetic structuring of populations within mountain ranges corresponds to dispersal traits. This structure is considered within the context of evolutionarily significant units, current catchment management based approaches to the conservation of lotic systems given the increasing development of inter-basin water transfers.

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#### THE EFFECT OF LANDSCAPE STRUCTURE ON CRITICAL BIODIVERSITY.

Critical biodiversity is the level of species richness at which communities are most susceptible to disturbance, where even small perturbations may trigger mass extinction. Beyond this threshold, species spontaneously form ordered communities with well-defined spatial structure and mass extinction no longer occurs unless globally perturbed. Do communities naturally evolve to the critical biodiversity point? We adopted a complex systems approach to explore how landscape pattern affected the critical biodiversity threshold ( $S_c$ ) in heterogeneous random and fractal landscapes. Communities that evolved in random and clumped fractal landscapes had nearly the same average richness (random  $S = 22.0$ , fractal  $S = 20.5$ ), but the range of variation among evolutionary trajectories was 3x greater in random landscapes (random CV = 66%, fractal CV = 21%). Critical biodiversity increased in landscapes with high spatial contagion (random  $S_c = 15$ ; clumped fractal  $S_c = 20$ ) and there was a striking tendency for communities on clumped fractal landscapes to evolve to the critical biodiversity threshold. Spatial structure is not a prerequisite for community organization, but organized communities are inevitable in highly structured landscapes. Order begets order and this order reduces the susceptibility of communities to local perturbations and mass extinction.

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#### RAT ERADICATION FOR ENDANGERED SPECIES PROTECTION ON BUCK ISLAND, ST. CROIX, U.S.V.I.

Introduced roof rats (*Rattus rattus*) have caused severe damage to the flora and fauna of Buck Island, a 72 - ha island managed by the U.S. NPS. In particular, heavy rat depredation has been documented on sea turtle nests. These impacts lead to the design and implementation of a rat eradication program using a 0.005% diphacinone wax bait block in bait stations. Following regulatory approval and pre-treatment monitoring a 50 by 50 m grid of bait stations (420 total) was placed on the island. Bait stations were elevated and modified to reduce non-target hazards (e.g. land crabs bait consumption). After two 2-week baiting sessions, only one rat was captured during standardized rat population monitoring. Following a second baiting session with a different flavored bait block, no rats were captured. Supplementary rodent baiting was conducted near sea turtle nest sites due to an unverified report of a rat near this site. No rat captures have been documented during post-treatment rodent trapping but house mice (*Mus musculus*), previously unknown to the island, have been captured. A monitoring program is in place to assure that the rat eradication has been successful and to assess the growing mouse population and its potential impacts.

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#### SEASONAL COLONIZATION PATTERNS AND COMMUNITY DEVELOPMENT OF BENTHIC INVERTEBRATES IN A HAWAIIAN STREAM.

Field studies were conducted in the Wainiha River on the north shore of the island of Kauai, Hawai'i, to examine the effects of seasonality on colonization rates and patterns of stream benthic macroinvertebrate communities. In four trials over a one-year period (1996-97) during spring, summer, fall, and winter, macroinvertebrates were collected at pre-determined intervals for up to 60 days from initially denuded cobbles placed along a single 25 meter reach. Macroinvertebrate community structure was analyzed using multivariate techniques and ordination. Among the

environmental variables measured; mean discharge, water temperature, and light showed significant differences among the seasons and were correlated with colonization patterns and community composition of macroinvertebrates. No seasonal differences in the number of macroinvertebrate taxa colonizing the cobbles were detected. Total macroinvertebrate densities increased more rapidly in spring and summer than in fall and winter. The densities of the dominant macroinvertebrate species increased more rapidly in spring and summer, corresponding with reproductive peaks, than in fall and winter, except for the chironomid *Cricotopus bicinctus*, which showed similar rates of increase in all seasons. In comparison to the continental U.S., Hawaiian benthic invertebrate communities are of limited diversity and are dominated by alien species.

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#### CONGENER DIVERSITY MAY INDIRECTLY FACILITATE MUSSEL INVASION.

The role of community diversity in moderating invasion success is much debated. There exists apparently contradictory evidence that invasion success is correlated with both high and low native diversity, and may be inhibited or facilitated by individual native species. I present experimental results illustrating the mechanism whereby a native congener indirectly increases an invader's potential for success. I tested the ability of the Mediterranean mussel *Mytilus galloprovincialis* to invade the rocky shores of two Pacific Northwest islands, wave-exposed Tatoosh and sheltered Saddlebag. On both islands, the predatory seastar *Pisaster ochraceus* is abundant. On Tatoosh island where the preferred prey of *Pisaster*, *M. californianus*, is found, transplanted *M. galloprovincialis* survive well. In contrast, on Saddlebag Island where *M. californianus* is absent, transplanted *M. galloprovincialis* are rapidly consumed by *Pisaster*. The spatial arrangement of *M. californianus* on Tatoosh island creates a refuge where *M. galloprovincialis* can survive. *M. californianus* lives low in the intertidal, so *Pisaster* do not need to forage higher up, and *M. galloprovincialis* can survive above the *M. californianus* zone. On Saddlebag, *M. californianus* is absent because of insufficient wave action, and *Pisaster* forages throughout the intertidal, there is no spatial refuge for a successful invasion by *M. galloprovincialis*.

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#### HABITATS WITHIN HABITATS: OR "IT'S A SMALL WORLD AFTER ALL".

Traditionally, conservation of habitats has been focused at the ecosystem or landscape scales. Insects generally respond to conditions at the microhabitat level and can be used as indicators of habitat quality. More recently, some insect species have become the target of conservation efforts with the increasing recognition that they are in fact threatened. In terrestrial ecosystems, this is often due to the scarcity of host plants. We have conducted insect sampling in managed forests as an effort to determine the impacts of management practices on a range of insect species in Maine. Comparisons were made between stands representing extremes in forest stand types, including recent clearcuts, thinned mature stands, and dense spruce-fir thickets. The stands with mature trees provided better conditions for insects associated with fungi and Psocoptera (barklice). The former may be a reflection of moister conditions below the canopy, whereas the latter was undoubtedly due to the increase in bark surfaces provided by mature trees. Taxa which rely on flowering plants were substantially more scarce in the spruce-fir thickets which had very little understory vegetation. In a separate study, it was found that floral resources were not diminished by the use of herbicides.

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#### THE RELATIONSHIP BETWEEN BUTTERFLY COMMUNITY COMPOSITION AND PRAIRIE CONDITION.

Large-scale restoration would be difficult on native prairie in Oregon because >99% of prairie area has been lost. Protection, restoration, and management of small prairie parcels may offer the greatest opportunity for conservation of organisms that rely on these systems. We chose butterflies as indicators of prairie condition and examined the relationship of butterfly diversity, richness, and density with vegetative cover at sites (N=17) of differing quality in the Willamette Valley, Oregon. We evaluated and interpreted the relative likelihood of alternative models explaining butterfly diversity, richness, and density with cover of native plant, butterfly larval host-plant, and butterfly nectar source species. Preliminary results suggest butterfly diversity increased as native plant cover increased; however, the effect was small. Butterfly richness and density of Parsley-, shrub-, and tree-feeder butterflies were positively associated with native plant cover but negatively associated with host-plant cover. Native plant, host-plant, and nectar source cover did not affect densities of Mallow-, Fumitory-, Mustard-, Violet-, Pea-, Composite-, and grass-feeder

butterflies. These preliminary results suggest that butterfly richness, density, and diversity are affected by patch-specific vegetation characteristics in a species-specific manner, and that such effects are generally small. The relative role of patch-specific and landscape factors remains to be investigated.

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#### MODELLING EFFECTS OF GENETIC SELF-INCOMPATIBILITY SYSTEMS ON PLANT POPULATION VIABILITY.

Several recent studies have identified low genetic diversity at self-incompatibility (SI) loci as a cause of reduced seed set in small populations of endangered plants. Here we use a biologically realistic, spatially explicit, simulation model to explore the genetic and demographic consequences of three kinds of self-incompatibility: gametophytic; sporophytic with codominant *S* alleles; sporophytic with linear dominance of *S* alleles, for model species with a range of birth and death rates simulating annuals through to long-lived perennials (20 years). Results show that SI systems can constrain the viability of small genetically depauperate plant populations through their effects on mate availability, mean seed set and the skewedness of fitness distributions which influences effective population size. Sporophytic systems with codominant expression of *S* alleles are generally the demographically most limiting, however the magnitude of the effects of SI system on population viability does depend on plant life history as defined by birth and death rates. As approximately one half of the angiosperms are thought to have genetically controlled SI systems the implications for conservation of endangered plants species are significant.

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#### SELECTIVE MORTALITY, LIFE HISTORY COMPLEXITY, AND THE EFFECTS OF DAMS ON CHINOOK SALMON.

We tested for selective mortality in chinook salmon (*Oncorhynchus tshawytscha*) as a function of their juvenile length and timing of downstream migration. Actively migrating juveniles were captured, tagged and released in 1995 and 1996 approximately 700 km upstream from the Pacific Ocean, and returning adults were detected at the same location. Thus survival was measured over a major portion of their life cycle. We detected selection for juvenile length in most of the groups analyzed. Length at migration is a result of factors encountered in early life stages but selectively determines mortality in the juvenile -to-adult stage. Thus freshwater habitat improvements directed at increasing growth may result in an increase in overall survival. For fish that migrated in 1995, we detected selection for earlier migrational timing. The development of hydroelectric dams in the migratory corridors of these fish has delayed their arrival timing to the estuary. Mitigation efforts, such as flow augmentation or dam breaching, that would shift arrival timing toward that experienced prior to impoundment may confer considerable survival benefits for these threatened fish.

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#### ECOSYSTEM EFFECTS OF NATIVE SHRUB COLONIZATION IN EXOTIC-DOMINATED CALIFORNIA GRASSLANDS.

Coyotebush (*Baccharis pilularis* var. *consanguinea*) is a native shrub that establishes episodically in California's exotic-dominated grasslands where grazing is absent. We examined the long-term effects of natural coyotebush colonization on plant community composition, ecosystem functioning (NPP, carbon and nitrogen storage, moisture availability), and soil characteristics (soil aggregate stability, microbial activity, and glomalin concentrations). We used historical aerial photographs to identify a gradient of sites, ranging in time since shrub establishment from 0 (control) to 25 years. Shrub colonization increased the relative biomass of native herbaceous understory species over time. Native oaks first appeared as seedlings under 15- year shrubs and were established in 3/4 of the 25-year sites. Carbon storage in plants, litter, and soil increased dramatically with time since colonization in association with increases in standing live and litter biomass. Declining NPP along the sequence was associated with gradual sequestration of carbon and nitrogen in woody biomass and litter. These results illustrate the potential for using coyotebush as a restoration tool in California annual grasslands. The progressive changes observed along the 25-year gradient illustrate that colonization by native shrubs can have strong effects on grassland functioning that take decades to fully develop.

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#### RESEARCH ON THE LAST, VIABLE POPULATION OF SPEYERIA IDALIA BUTTERFLY IN ITS EASTERN RANGE.

The Pennsylvania population of the regal fritillary butterfly (*Speyeria idalia*) is the last known, viable population in its eastern range. *S. idalia* is in essence an island isolated geographically from other populations. This population inhabits a military installation. The Nature Conservancy with the military's support has studied this population since 1992. Census routes, conducted during the 1999 flight period, indicated that 80% of *S. idalia* were located at just two small sites, demonstrating the importance of maintaining these sites and improving habitat for other sites. *Asclepias tuberosa* was the preferred nectar source during the first six weeks of the adult lifecycle with *Cirsium* spp. being utilized exclusively in weeks 7 through 10. Current research is evaluating techniques to establish these two plants and *A. syriaca*. A larval host plant (*Viola*) study indicated that violet rhizomes were successfully established in scarified ground in 1995. The survival rate was at least 80% in 1996 and 76% in 1997 with 144 new violets in 1997. The survival of this population is critical in reestablishing *S. idalia* in its eastern range. Research on this population is imperative in maintaining its long-term persistence at this location and promoting its recovery in its eastern range.

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#### GERMINATION AND ESTABLISHMENT OF *LOPHOPHORA DIFFUSA* (CACTACEAE) IN RELATION TO MICROHABITATS: IMPLICATIONS FOR CONSERVATION.

Germination and establishment of cacti species, *Lophophora diffusa*, were studied experimentally. Status ecological for the species is threatened and endemic to restric zone semiarid in central Mexico and whose juveniles individuals are collected as ornamental plants, addition to intensive grazing and land clearing for cultivation, out come a disminution of possibilities to remain in long-term. A field study was conducted to determine relationship between *L. diffusa* and its nurse plants. The results shows a strong association with two perennial plants, *Larrea tridentata* and *Celtis pallida*, providing a microhabitat suitable for seedling stablishment, so the abundance individuals is more under canopy these plants. Germination percentage is relative high (until 60%), the stablishment is the most critical stage for species. Conservation of this species should be promoted because is a species endemic, its habitat is strongly disturbed, is a species of slow-growing. The remain of this species in nature depend of protection of nurse plant, decreases of grazing, a halt to illegal extraction and protected areas.