BLACK BEAR ABUNDANCE AND SEASONAL FORAGE HABITAT VALUE IN WHISTLER, BRITISH COLUMBIA

by

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ABSTRACT

Forage habitat values and bear abundance were identified as leading research needs within the RMOW to achieve "Bear Smart Status", a recognition program used to recognize communities that are bear proofing their community and ultimately reducing human and bear conflicts.

Hair samples were collected using non-invasive barbed wire hair snagging sites to gather hair roots for genetic tags. I used coarse scale and fine scale methods for delineating bear forage habitat values at hair snagging sites. I calculated habitat value indices for bear foods in each season. I examined the relationship between two methods for delineating forage habitat value and between forage habitat value, distance from urban areas, and bear abundance at hair snagging sites.

Fifty-nine individuals were identified, 30 female and 29 male. I found there was a positive correlation between these variables for females but not for males; there was also a significant correlation between the methods for delineating habitat value.

Keywords: genetic tagging; black bears; habitat; Bear Smart Status

DEDICATION

To my Grandpa Dennis Jenkins

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1 INTRODUCTION

1.1 Status of black bears in North America

Historically, black bears occupied most of North America except the treeless barrens of northern Canada and the desert regions of the south-western United States and Mexico (Figure 1). Today, the American black bear (Ursus Americanus) is widely distributed throughout North America, occurring in all Canadian provinces except Prince Edward Island, northern Mexico, and in 32 states of the United States (Figure 1), (Servheen, 1989). They have been displaced from the southern farmlands of Alberta, Saskatchewan and Manitoba. In the United States, black bears have lost habitat wherever hardwood forests have been eliminated and have been extirpated from most of Alabama, Kentucky, Ohio, and Illinois (Pelton, 1982). Once found ubiquitously and in relatively high numbers in continuous habitat across North America, American black bear populations have become increasingly fragmented and isolated (Polker and Hartwell 1973; Pelton 1982; Hummel and Pettigrew 1991; Lyons et al. 2003).

In British Columbia, black bears are the most widely distributed large mammal, virtually the entire province, including the outer coast and islands, is occupied black bear habitat. Humans have settled 8% of the province, primarily in the Lower Mainland, south-eastern Vancouver Island and the Okanogan, but even parts of the densely settled areas still support black bears. Only about 5% of the total area of the province has been permanently lost as black bear habitat. However, black bears are sensitive to human activities due to their large home ranges, low population densities and reproductive rates and hence have been extirpated in areas of heavy human settlement (Hebblewhite et al. 2003). Black bears are more adaptable to humans and human settlement than grizzly bears; as a result, they continue to occupy 85% of their historic range (Davis et al. 2002), and are therefore not listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) nor are they considered a species at risk (yellow-listed) in British Columbia (BC Conservation Data Centre). The population of black bears in British Columbia is estimated to range between 120,000 and 160,000 individuals (Demarchi et al. 2000). This is nearly 30% of the 443,000 black bears in the Canadian population and approximately 15% of the 803,000 black bears in the North American population.

1.2 Conflict between bears and humans

Human developments and activities such as roads, towns, and agriculture can block animal movements and fragment the landscape (McCrory, 2003). In an increasingly fragmented landscape, bears are forced to use smaller and smaller patches of quality habitat. Habitat fragmentation occurs when natural topographic features (e.g., mountains, rivers) or human disturbances divide wildlife habitat into smaller, relatively ineffective fragments (Noss, 1991). Habitat fragmentation results in the loss or isolation of effective wildlife habitat and is widely recognized as a leading cause in the loss of biodiversity. It is essential that bears maintain the ability to move between these habitat patches to fullfill daily and seasonal needs. Habitat connectivity is critical for ensuring the long-term persistence of bears and many other species. Reducing habitat connectivity can have significant implications for long-term bear conservation and even more so if it results in regional populations becoming cut off, or isolated from one another, because isolated populations experience little or no emigration (Noss, 1991). This results in a decreased ability to respond to short- and long-term changes in their habitat (e.g., changes resulting from a forest fire, climate change, or from human disturbance). Relatively small isolated populations, eventually show reduced genetic variability. However high genetic variability is generally regarded as important in maintaining high levels of fitness which allows for adaptation to a changing environment.

British Columbia's landscape has become increasingly fragmented, in part due to a rapidly expanding human population, which has encroached upon prime natural bear habitat. As a result, habitat loss, alteration, alienation, and fragmentation have disrupted bears' use of natural habitat and ultimately resulted in negative impacts to individual bears and bear populations through displacement or mortality (Davis et al. 2002). Human population pressures in British Columbia have forced development into unaltered wilderness, thereby decreasing the suitability of the natural landscape for present bear populations. As human developments continue to expand and encroach into the natural landscape, non-natural feeding opportunities are introduced to resident bear populations such as garbage and bird feed to name a few. Unlike Grizzly bears, black bears appear to have a wider variety of habitat selection patterns, making them more resilient to human change (Davis et al. 2002). However, black bears that are not displaced as a result of increased human activity are drawn into the community by the availability of non-natural attractants. Black bears are opportunistic feeders and will therefore be quick to discover and take advantage of new feeding opportunities.

Black bears are curious animals that will be attracted to a new smell, sight or even noise. If bears are repeatedly exposed to this new stimulus without consequence, the bear becomes habituated to the stimulus. For example, as humans develop the landscape, bears are quickly introduced to the presence of humans. If a bear regularly encounters humans but is not rewarded with food or harmed, they simply get used to people. This is referred to as a habituated bear; such a bear will tolerate human presence at a much closer distance, while also reducing their fleeing response (McCullough 1982; Herrero 1985; Davis et al. 2002). It is possible that habituated bears can still coexist with humans, provided there has been no human food available for bears. Bears that have been rewarded with a non-natural food sourse such as garbage, can become food conditioned. Food conditioned bears behave differently from a bear that is only human-habituated (Herrero 1985; Gilbert 1989; Aumiller and Matt 1994). A food-conditioned bear simply forms an association such that 'people' may be followed by 'food' (Herrero, 2002). It only takes one rewarded occasion for a bear to become food-conditioned because they have the ability to learn from a single experience. Hence, habituation combined with food conditioning has been associated with a large number of bear deaths because these bears become aggressive to humans. The availability of non-natural attractants within a community can have several profound effects on bears living adjacent to the community. These effects, directly influence the likelihood of human-bear conflicts because human-habituated and food-conditioned bears have a higher probability of negative human encounters because they are more likely to come into contact with humans due to their attraction to human food and smells (Ciarniello, 1997).

Over the past ten years, British Columbia has experienced an escalation of black bear-human conflicts. The number of black bear complaints recorded by the Conservation Service nearly doubled between 1992 and 1999. BC Conservation Officers recorded an annual average of 8,811 complaints (Ministry of Water Land and Air Protection, 2000). On average 995 black bears are destroyed each year, in 1998 over 1,600 bears were killed and 1,728 bears were handled by conservation officers in control actions (Figure 2) (Ministry of water Land and Air Protection, 2000). The number of bears destroyed each year has increased as fewer bears are translocated each year due to high costs and the ineffectiveness of translocation and the additional problems it causes. Relocated bears may conflict with resident bear populations in habitat that is already occupied, resulting in the bears returning to their home territories and the site of conflict.

Managing human bear conflicts

Learning to coexist with bears has been, and will continue to be an exigent task. Coexistence means that both bears and humans, together, use the same environments, but where bears live without the exploitation of human foods (Herrero, 2002). It is crucial for effective management to understand what the desired relationship between bears and humans should be. This is summarized nicely in a park policy created for Glacier National Park

> "bear management policy is to maintain natural population dynamics, foster pristine habitat relationships, and encourage shyness as the characteristic behaviour of the bears in the presence of humans. Behaviours classified as defensive will be considered natural with management response directed toward human use control. Behaviours classified as aggressive will be considered undesirable with management response directed towards removal. Opportunity for expression of either behaviour will be minimized through park wide human use management. Tolerance of any behaviour, which leads to use of defined human use areas will be limited" (Gniadek et al. 1998).

This policy exemplifies that non-natural food sources such as garbage, must be controlled if bears and humans are to coexist. This may seem like a fairly simple task, but for communities that are located on the periphery of densely populated bear habitat, this has proven to be one of the most difficult wildlife challenges ever faced (Herrero, 1985, McCrory 2004, Davis et al. 2002). As stated earlier in this chapter, it only takes one careless citizen to create an aggressive food conditioned bear. However, this shift in management strategies from reactive management of "problem" bears to the proactive management of the attractants is being recognized all across North America.

1.3 Bear Smart Status in British Columbia

The Province of British Columbia has chosen to facilitate this change by accrediting communities with "Bear Smart Status," which will be granted to those communities that reach a benchmark level of proactive management of human and bear conflicts (Davis et al. 2002). The "Bear Smart Status" community program has been designed by the Ministry of Water, Land and Air Protection in partnership with the British Columbia Conservation Foundation and the Union of British Columbia Municipalities. It is a voluntary, preventative conservation measure that encourages communities, businesses and individuals to work together to address the root causes of bear-human conflicts, thereby reducing the risks to human safety and private property, as well as the number of bears that have to be destroyed each year. It has been recommended that achieving "Bear Smart Status" should be a two-stage process.

In Phase I, the sources of potential human-bear conflicts within the community are identified. This typically involves a preliminary bear hazard study and problem analysis with a focus on identifying non-natural and natural attractants. In Phase II, a human-bear management plan is developed and implemented. This management plan includes components on monitoring human-bear conflicts, education, managing waste, implementing and enforcing bylaws, managing green space, and community planning. The "Bear Smart Status" process is designed to be adaptive, so that new management options or improvements can be incorporated into each phase. Criteria for each step in the process are provided so that communities have clearly defined and achievable targets (Davis et al. 2002).

Ultimately, it is hoped that through this two stage process, communities granted 'Bear Smart Status" will use non-lethal techniques such as bear aversion, and thus reduce or eliminate the instances of 'problem' bears killed and injuries to humans or their property as a result of garbage conditioned or habituated bear. The bear smart program recognizes that despite all efforts to reduce human bear conflicts, incidences are still likely to occur (Davis et al. 2002). The attitudes and management strategies have become more proactive than reactive towards community-based stewardship of bears. However, despite this change, the challenge of eliminating non-natural bear attractants from communities has proven to be extremely difficult (McCrory, 2004). Consequently, at this time no community in British Columbia has yet qualified.

However, the Resort Municipality of Whistler (RMOW) has been one of the most progressive and active communities in British Columbia and stands out as exemplary in working to become bear proof. Areas in which Whistler have met these criteria set out in the Bear Smart program include bear-proof garbage receptacles for pedestrians, fencing of the entire landfill and changing gate systems, ongoing education programs, and enforcement of existing bylaws, especially with respect to housing of commercial dumpsters. Nevertheless, the transient tourist population and the small number of waste disposal units available for the use of local residents creates problems because people continue to dispose of their garbage in ways that attract bears. Whistler has made enormous progress on bear proofing its community, however, as recommended in the preliminary bear hazard assessment report (McCrory, 2004), research into the bear habitat potential, suitability, and use, within the RMOW was lacking greatly and is an important step in meeting the Bear Smart criteria. In a study of reducing human-bear conflicts in British Columbia, Ciarniello (1997) noted that the potential for human-bear conflict is increased if bear habitat values are not accounted for in the management decision. She also concluded that the maintenance of habitat and accommodation of natural movement patterns of bears are considered proactive management techniques and are preferred for mitigating bear-human conflicts. McCrory (2004) also noted that more intensive studies were needed in terms of detailed habitat ecology, diet, habitat mapping, and seasonal bear use and travel. My research supports the latter three areas which will aid in the RMOW reaching its goal of 'Bear Smart Status."

1.4 Research objectives

The RMOW has taken on the challenges of reducing conflict between both humans and bears along with bear proofing their community. Once achieved, the community could be recognized by becoming one of the first communities to be awarded with 'Bear Smart Status". To achieve this goal, managers need baseline information regarding habitat capabilities and bear use and abundance along with patterns and trends of bear distribution and movement throughout the RMOW. The maintenance of habitat and accommodation of natural movement patterns are important for reducing human bear conflicts and must therefore be accounted for in the management decisions. Currently, there is a lack of scientific documentation, detailing the habitat values and bear use within the RMOW. My research is aimed at addressing landscape and spatial level questions regarding habitat value and bear use along with methods for determining habitat value.

Objective 1. Obtain minimum population estimates for black bears within the RMOW using non-invasive genetic methods.

Objective 2. Examine seasonal patterns and trends of female and male black bear movements and distribution throughout the RMOW.

Objective 3. Determine bear forage habitat values for buffered hair snagging sites locations using coarse (Terrestrial Ecosystem Mapping and Biogeoclimatic Ecosystem Classification system) and fine scale (field transects) evaluations.

Objective 4. Examine the seasonal correlation between habitat forage value and black bear abundance at hair snagging sites.

Objective 5. Provide management recommendations concerning bear habitat use and bear-human conflicts in the Resort Municipality of Whistler.

2 STUDY AREA

2.1 Vegetation, regional climate and geology

The Resort Municipality of Whistler (RMOW) is situated in the Pacific Ranges of British Columbia, only 40 km inland from the Pacific Ocean, and 120 km from Vancouver, one of Canada's largest urban centres (Figure 3). The resort municipality of Whistler consists of 165 km^2 that encompass four biogeoclimatic subzones (Figure 3). Vegetation in British Columbia is classified within the framework of the Biogeoclimatic Ecosystem Classification System (Meidinger and Pojar, 1991). The BEC system is a hierarchal classification that combines three major classifications: climatic, vegetation, and site. Ecosystems are classified at the biogeoclimatic zone level (e.g., the Coastal Western Hemlock zone or the CWH) reflecting differences in regional climate, at the subzone level (e.g., the Coastal Western Hemlock moist submaritme zone or the CWHms) reflecting meaningful differences in climate within a zone, and at the variant level (e.g., the Coastal Western Hemlock Southern Moist Submaritme zone or the CWHms1) reflecting subtle differences in local climate.

The Southern Moist Submaritime Coastal Western Hemlock Variant (CWHms1) makes up the largest portion (63.95%) within the RMOW (Table 1). The CWHms1 is distributed from the valley bottom up to about 1200 m elevation where it grades into the MH Zone. The climate is transitional between the coast and interior, and is characterized by moist, cool winters and cool but relatively dry summers. The dominant tree species in the CWH is western hemlock (*Tsuga heterophylla*), with some old-growth western red cedar (*Thuja plicata*), yellow cedar (*Chamaecyparis nootkatensis*), and amabilis fir (*Abies amabilis*). The snowfall in this zone is relatively heavy, particularly in upper elevations.

The second largest percent cover is the Leeward Moist Maritime Mountain Hemlock Variant (MHmm2), which makes up (20.14%) of the RMOW (Table 4). The MHmm2 occurs above the CWHms1, beginning at about 1200 m elevation. It tends to be higher on major warm aspect slopes where it may come in at 1400 m. It occurs at lower elevations on plateaus and cold bowls where the subdued topography creates longer duration snow-packs. The climate features long, moist, cold winters, and short, cool summers. The dominant tree species in the MHmm2 include mountain hemlock, amabilis fir, western hemlock and subalpine fir (*Abies lasiocarpa*).

The last two Biogeoclimatic zones consist of a small portion of the study area. They include the Leeward Moist Maritime Parkland Mountain Hemlock variant (MHmmp2) and The Coastal Alpine Tundra subzone (ATc) Table 4). The MHmmp2 is characterized by discontinuous forest cover and is distributed where physiography and elevation combine to create snowpacks of sufficient duration to preclude continuous forest cover. The MHmmp2 occurs above the MHmm2. Because topography significantly affects snowpack patterns, the distribution of the MHmmp2 is often non-contiguous throughout the study area. The MHmmp2 contain amabilis fir, subalpine fir, mountain hemlock and yellow cedar. The ATc occurs on upper mountain slopes and peaks where the climate is so harsh that the forest cannot establish, it occurs above the MHmmp2.

The climatic information for both the CWHms1 and the MHmm2, the two dominant zones in the RMOW are characteristic of montane and subalpine ecosystems in south-western British Columbia. The CWHms1 has maximum mean monthly temperature of 15°C, a minimum mean monthly temperature of –4.4°C, 116 frost-free days, and a mean annual precipitation of 1415 mm including 657 cm of accumulated snowfall (Alta Lake/Whistler, B.C at 668 m elevation), (Stamp, 2003). The MHmm2 has a maximum mean monthly temperature of 11.3°C, and a minimum mean monthly temperature of –9.1 °C, 56 frost-free days, and a mean annual precipitation of 1995 mm, including 1041 cm of accumulated snowfall (Tahtsa Lake West at 863m elevation), (Stamp, 2003).

The RMOW represents the Rugged Pacific Ranges Regional Landscape. This landscape is characterized by high jagged, ice-blanketed peaks above steep-sided forested mountain slopes which plunge to u-shaped valleys at relatively low elevations. The climate is typical of the West Coast being determined by the eastern movement of moisture laden air resulting in high precipitation and mild temperatures.

The Granite Mountains of the Rugged Pacific Ranges contain the highest peaks in the Coast Mountains from Mount Waddington in the north, at over 4000 m, to Mount Garibaldi in the south at nearly 2700 m. Physiographically, the RMOW is typical and representative of this regional landscape. Lower mountain peaks have been sculptured by cirque glaciers as evident by rounded and domed peaks. Mountain slopes are steep sided and densely forested, while the lower elevation u-shaped valleys bear further evidence of the glacial process. Typically, the landscape has a rectangular type drainage pattern with glaciers and snowfields.

The Pacific Ranges are the result of major geologic events that have occurred since their formation 135 - 181 million years ago. They were formed during the Jurassic Period by a large mass of intrusive igneous rock called the Coast Batholith. Many other events including volcanic eruptions and the metamorphic granite intrusion and uplifting created this landscape. It was however, the glacial periods, which sculpted the mountains landscape as it is today. The bedrock in the RMOW is composed of sedimentary, metamorphic igneous and volcanic rocks.

2.2 Urban development and population

Human settlement and development have a long history within the RMOW. The development in Whistler has been mainly a result of tourism, which began as far back as 1914 when Alex and Myrtle Philips purchased 10 acres of land and opened Rainbow Lodge on the shores of Alta Lake. In the same year, the Pacific Great Eastern Railway opened, allowing easy travel to Rainbow Lodge. This quickly made it the most popular resort destination west of Banff and Jasper. Additional lodges opened up on Alta Lake and other lakes in the Valley. The fish were abundant and the recreation activities excellent; because of this Whistler was a successful summer resort 50 years before it was discovered as a ski destination.

Since then, two ski hills have opened. February 14, 1966 Whistler officially opened for skiers. At this time the permanent population of the Whistler Valley was approximately 25 people. In 1975, the rapidly growing community of Alta Lake became the first and only Resort Municipality in Canada. A plan for the town site was formed in 1977, and by 1980 Blackcomb mountain opened and the new village was up and running.

The Resort Municipality of Whistler has become a four-season destination. Today there exists an extensive network of hiking and biking trails both on and off the mountain, three 18 hole golf courses, and Highway 99, which runs directly through the centre of the municipality.

The RMOW has developed into primarily a resort town which is reflected in its fluctuating population. There are currently 9,500 permanent residents and addition to permanent residents Whistler is a part-time home to approximately 9,100-second homeowners, and 4,500 season residents. With overnight and day visitors, the per day population averages 31,351 in winter and peaks (usually around New Year's) at approximately 45,000. Whistler's population is projected to grow at an annual rate of permanent residents by 2.29% for a total projected municipal population of 15,000 by 2020 and 22,234 in 2031. As a result the Municipal Council has implemented a bed unit count or bed cap which restrict the growth capacity. Whistlers' main village has almost reached its building capacity and Village North is not far behind. The majority of bed units available for development are located in Whistler Creek, some of which are single-family building lots but the vast majority of bed units are allocated to be condominium units.

The Resort Municipality of Whistler in conjunction with the city of Vancouver will also be hosting the 2010 Winter Olympic and Para Olympic Games and will host the nordic, alpine and sledding events of the Olympic Games during February 2010 and the Para Olympic Games during March, 2010.

2.3 Other mammal species

With such an abundance of diverse landscapes and ecological zones Whistler is home to a large number of mammal species. Common mammals include the beaver

(*Castor canadensis*) and river otter (*Lontra canadensis*), which inhabit the Whistler wetlands along with raccoons (*Procyon lotor*), squirrels (*Tamiasciurus donslasi*) and pika (*Ochotona princeps*). Coyote (*Canis latrans*), cougar (*Felis concolor*), and wolverine (*Gulo gulo*) are also known to occur. Columbian black-tailed deer (*Odocoileus hemionus columbianus*) is the main ungulate species with some mountain goats (*Oreamnos americanus*) occurring at high elevation. The grizzly bear (*Ursus arctos*) has been extirpated from the area, although a recovery program for the region is under consideration by the Province (McCrory, 2004).

3 METHODS

3.1 Study design for hair collection

3.1.1 Non-invasive hair snagging sitesping and field sampling

Identifying free-ranging black bears in the coastal Pacific ranges of British Columbia is a difficult task for wildlife biologists due to the densely forested and mountainous landscapes; moreover, the lack of distinguishing features (e.g., scars, unique colour patterns), cost and invasiveness of physical capture, poor visibility, and mark loss are also contributing factors (Woods et al. 1999). Although conventional bear studies rely on radio telemetry with its attendant hair snagging sitesping, collaring, and aerial tracking, new genetic technology now allows scientists to identify the species, sex, and individual identity of bears from small samples of hair or scat collected, long after the bear has moved on (Mowat and Strobeck, 1999). Conservation genetics and DNA sampling techniques are relatively new in wildlife management and their applications are diverse. In Japan, DNA studies are being used to identify threatened and endangered whale species sold as meat products in the marketplace. While similar studies include genetic work on Andean Spectacle bears, grizzly bears, wolverines, and lynx.

Today however, non-invasive DNA-based techniques have become a routine approach to population inventory for black bears and brown bears (Taberlet et al. 1997; Woods et al. 1999; Mowat and Strobeck 2000; Poole et al. 2001; Boulanger et al. 2003). The idea of these studies are to use non-invasive hair sampling techniques to snag hair from animals, without ever seeing, touching, or capturing the animal of interest (Figure 4). Once hair samples are collected, DNA extracted from the hair follicle can then be analyzed in the laboratory for species, sex, individual identification, genetic diversity, and even parent-offspring relationships. Roots from mammalian hair contain sufficient DNA for analysis; however, the genetic material at specific loci must be amplified using the polymerase chain reaction (PCR) (Higuchi et al. 1988). Bears release hair both easily and frequently on rub trees, in beds, and at foraging sites making them ideal applicants for this type of study. Because bears are attracted to scent lures, methods to obtain hair samples permits systematic sampling regimes, necessary for many ecological studies (Woods et al. 1999).

In 2002, the Whistler Black Bear Project conducted a field trial using genetic tagging within the RMOW, based on the design tested by Woods et al. (1999). Because the project was successful in collecting a substantial number of hair samples, a more extensive project was initiated for spring 2003. We built enclosure hair-hair snagging sites by running a single strand of barbed wire around several trees and uniformly 50 cm above the ground. When necessary, we filled in the terrain irregularities with woody debris to ensure uniform wire height. Standard fencing staples fastened the wire to each of the trees, and we hand tensioned the wire (Woods et al. 1999). Each site was scented with approximately 125 ml of natural fish fertilizer. The fertilizers was poured into burlap sac, and then suspended four to five meters in height across the enclosed site.
The intent of this design was to attract the bear into the enclosure without providing the bear with a food reward; two to four warning signs for residents were placed around the hair snagging sites depending on its proximity to trails and other developments.

We constructed 51 hair snagging sites throughout the RMOW, however, only 48 of those were used for the purposes of this research project (Figure 5). The objective for the placement of the hair snagging sites was to identify as many individual bears as possible within close proximity to urban and developed areas, and high use recreation areas. We placed 34 of the hair snagging sites around the valley bottom within the CWMms1 biogeoclimatic zone and 14 on both Whistler and Blackcomb Mountain within the MHmm1 and MHmmp1 zones. Due to restrictions imposed by the Municipality, the hair snagging sites were required to be no closer than 300 m to the nearest trail, road or other developments. Consequently, it was difficult to use any precise grid pattern and density. The snag sites were therefore placed approximately 500 m apart within the perimeter of the upper and lower village, housing developments, parks, golf courses, and hiking and biking trails. Because each of the hair snagging sites was within 30 minutes walking distance from a road; a helicopter was therefore not required. Weather however, was still a factor. During the last two weeks of October, the Whistler, Squamish, and Pemberton areas received an above average rainfall, resulting in the closure of Highway 99 at either end of Whistler. From October 17-21, 455 mm of rain fell ,which had broken the previous record. Geological engineer Frank Baumann, said the event was "the flood of a record," noting that flooding of this magnitude happens only once every 100 or 200 years. I believe this high precipitation had an effect on the abundance of hair samples collected during this time. As a result of such a heavy rainfall, hair samples were washed off the barbwire. Consequently, some hair samples were retrieved from the ground a few feet from the hair snagging sites and used for the analyzes.

Due to both funding and time constraints, we were unable to inaugurate the hair snagging with a spring session. We activated the hair snagging during summer, which began July 3, 2003 and finished August 4, 2003. We re-activated the hair snagging sites for the fall hair snagging on August 19, 2003, and the sampling sessions were completed on November 11, 2003. We visited the hair snagging sites at approximately 7-day intervals, removed hair samples, and refreshed the scent lure. We ran a white card behind the entire barb wire strand to ensure careful examination of each barb, reducing the chance of missed or lost hair samples. Each sample was then placed in a small envelope with the necessary information and air-dried at room temperature and stored in zip-lock plastic bags with desiccant (silica) to prevent degradation from moisture. Samples were submitted for analyzes to Dr. David Paetkau at Wildlife Genetics International Ltd. in Nelson, B.C.

3.1.2 DNA extraction

The variability of the available markers was tested to confirm whether there was sufficient information content in the markers to address the questions. The markers were then narrowed to the minimum set of maximally variable (informative) markers needed to answer a given question. The Wildlife Genetics Lab referred to existing data from other parts of British Columbia to identify a set of 12 markers that they felt were likely to be similar to bears in Whistler. As a result, 15 samples (one of which failed) were selected on which to test these markers. After excluding mixed or failed genotypes, as well as duplicate samples with identical genotypes, data were left from 11 to 12 individuals per marker (Paetkau, 2004).

All samples were extracted using QIAGEN's DNeasy Tissue kits following the manufacturer's instructions (search http://www.qiagen.com/ for details). The aim was to use 10 guard hair roots where available. When under-furs were used, the number recorded was an estimate because entire clumps of whole under-fur were extracted rather than clipping individual roots. An estimate of the amount of the leftover hair was made using three classes: no guard hairs; 1 to 4 guard hairs; more than 4 guard hairs (Paetkau, 2004).

Routine genotyping was conducted where six-locus genetic analysis was performed in three phases. The first included an initial pass using all six markers; any mixed DNA or samples producing data for fewer than three loci were excluded. Secondly, samples that produced incomplete data on the first pass, but that were not excluded as *Xbomb* or *Xmixed*, were run again in the hope of filling in missing data. In the third phase of genotyping, the remaining samples were subjected to an exhaustive computerized comparison of all pairs of unique genotypes, flagging suspiciously similar pairs of genotypes of the sort that could result from genotyping errors (Paetkau, 2004).

3.1.3 Individual identification and sex determination

Once the genotypes were completed and checked for errors, a computer search for identical genotypes was performed and individuals were defined for each unique genotype. Each individual was assigned a number that was cross-referenced in the 'Individual' column of the 'Samples' worksheet, and the 'List of Samples' column of the 'Individuals worksheet' (A6). A gender analysis was later conducted based on a size polymorphism in the amelogenin gene. The level error in assigning gender to samples was minimized by making the Y-chromosome allele shorter than the X-chromosome allele (short alleles amplify more strongly than weak ones), selecting primers that amplify exceptionally well, and being very conservative about re-analyzing weak female genotypes. Allelic dropout affecting the Y chromosome allele producing false female results however was still possible (Paetkau, 2004).

3.2 Study design for habitat ranking

3.2.1 Identifying bear foods and their seasonal use

When defining black bear foraging seasons for the purpose of habitat research, seasons may be defined according to the calendar definition or annual events that are pertinent to black bear biology and foraging behaviour. I delineated the seasons for my research such that they correspond to black bear biology and foraging behaviour. Some of the specific parameters I considered, included the times of year with no snow (green-up), depth of snow during spring and late fall, along with the berry-ripening season. At the time of this research, there had been no published work detailing the foraging requirements for black bears in Whistler. For that reason, I conducted a comprehensive literature review to obtain information on foraging behaviours of black bears from nearby ecosystems (Grant 1989; McCrory 1998; Noble and Meslow 1998; Gaines 2001; Stamp 2003; McCrory, 2004). This was followed by field observations of seasonal foraging behaviour in Whistler. A comprehensive list was created (Table 13) detailing incidental, occasional and preferred bear food plant species. For the purpose of ranking the habitat at hair snagging sites, a refined seasonal bear food species list was created in conjunction with the expert opinion of senior bear biologist Wayne McCrory whom has specialized in bear habitat ranking in neighbouring areas, including Duffey Lake Provincial Park, south Garibaldi Provincial Park (Diamond Head area), upper Elaho River and three provincial parks in the B.C North Cascades (Tables 9, 10, 11). The assumption was made that incidental and non-forage species have little influence on foraging behaviour of black bears.

3.2.2 Using coarse and fine scale methods for ranking forage habitat

I developed two methods for ranking forage habitat for black bears in and around the hair snagging sites throughout the Resort Municipality of Whistler. Applying a habitat value to a particular area by conducting extensive field observations is the most accurate method for ranking habitat (McCrory, 2004), however; most bear study areas encompass large amounts of terrain with difficult access. It is therefore, not easy or cost effective to evaluate the entire habitat through field observations. For this reason, I have tested both field observation transects as one method for habitat ranking and an entirely in house based approach using the data from the Terrestrial Ecosystem Mapping as the second approach. I created a 250m buffer around each of the hair snagging sites, which I used as the bases to test the aforementioned ranking methods. I used the program JMP IN 4 to run a non-parametric, multivariate correlation to examine the relationship between the two-forage habitat ranking methods. Additionally, I was able to test the relationship between bear abundance at the hair snagging sites and forage habitat value.

Identifying forage habitat values using Terrestrial Ecosystem Mapping (TEM)

Habitat cover was delineated through the use of Terrestrial Ecosystem Mapping (TEM) that was conducted by B.A. Blackwell and Associates Ltd. and requested by the Resort Municipality of Whistler. The RMOW has adopted an ecosystem-based approach in its Environmental Strategy (RMOW, 2002), and therefore required baseline data on the types of ecosystems present within the municipality. The objective of the TEM was to provide an ecological framework to support conservation planning and therefore represent a medium-scale inventory that is appropriate for landscape-level planning applications. The mapping procedures followed the general methods outlined in Standards for Terrestrial Ecosystem Mapping in British Columbia (RIC, 1998) with some modifications to meet project objectives. Areas with similar ecosystems were delineated on aerial photographs followed by field data collections to characterize ecological properties. The principal ecological features recognized in the delineations include site units, structural stage, and site modifiers. All data were compiled in a digital GIS (Geographic Information System) database (Green, 2004).

I used ESRIS's program ArcView 3.1 geographic information system to spatially analyze bear forage habitat in the RMOW. GIS has emerged as a key technology to manipulate and analyze spatial data to assist decision makers; and is commonly defined as an information system that manages, manipulates, and analyzes spatial data.

The hair snagging locations were recorded using a hand held Global Positioning System (GPS) and recorded as UTM coordinates (Universal Transverse Mercator Projection) and overlaid into ArcView. A buffer distance of 250m was applied from the attribute field, which in this case was the hair snag site. Many of the buffered sites had polygons, which fell, outside the new-buffered area; as a result they were recalculated to ensure that all polygons fell within the buffered area. The data table for each of the polygons in each buffered area was transferred into Microsoft Excel where a percent habitat cover table was created using site classification site series, which indicate its position on the edatopic grid. The data were then graphed.

I compiled a list of each of the site series classifications that fell within all of the buffered hair snagging sites. I derived seasonal weighting coefficients for each of the site series classification based on the list of preferred and occasionally used bear foods (see Section 1.4). I also examined other studies with similar ecosystems for information on seasonal diet composition of black bears, which is also described in more detail in section 1.4. Furthermore, the coefficients I used only accounted for the percent composition of each food plant group out of the vegetation fraction of their diet during each season. I then calculated an index of habitat values using abundance and seasonal dietary proportions.

The forage habitat values applied to each of the site series classifications were in increments of ten ranging from 10 to 60, which was equivalent to very low, low, moderate, high, and very high habitat quality. This range in habitat value was applied to each season and then multiplied by the percent cover in each of the hair snagging sites. For example:

HVs= ∑ [t%Css01CWH*ss01su, t%Css04CWH*ss04su, t%CssPLCWH*ssplsu]

where:

- HVs is the habitat value score for the 250m buffered hair snag site during the summer;
- t%Css01CWH, t%Css04CWH, t%CssplCWH are the total percent cover for site series classification (01) in the Coastal Western Hemlock zone

- ss01su, ss04su, ssplsu, are the weighting coefficients for the specific site series classification in summer

The results were compiled into a table and reclassified where: 1-10 = 1 (Very low), 11-20=2 (Low), 21-30= 3 (Moderate), 31-40=4(High), 41> =(Very high). This conversion was conducted to compare the results from the fine scale method based on field transects (McCrory, personal communication, 2005)

Identifying forage habitat values using ground transects

Emphasis was placed on ground-truthing each polygon within the buffered area and ground-truthing each site series classification within each of the polygons. At least one strip transect was conducted for each site series classification in the buffered area. The other method employed included 4-m-wide strip along random transects combined with select microsite plots. The strip transects followed Hamer and Herrero (1983) and McCrory et al. (1986). Along each transect or microsite plot the relative abundance of each important bear food was estimated according to the following: very low (VL = 0-5%), low (L = 6-10%), moderate (M = 10-50%), high (H = 51-80%), and very high (VH = 80-100%). Plant phenology and bear signs were also recorded. All scat locations were recorded in the field and partial food content of scats was determined from appearance of food items (green vegetation, berries, insects, etc.). A habitat value was derived for each of the buffered hair snagging sites based on the latter information and re-classified, where: very low = 1, low = 2, moderate =3, high =4, very high = 5, to compare the forage habitat values derived using the terrestrial ecosystem mapping (TEM). I developed spatial maps using ArcView GIS to gain more insight into the distribution of habitat value throughout the RMOW.

3.3 Analysis

3.3.1 Bear abundance and sex identification

Analysing the abundance of black bears at hair snagging sites was necessary to test the relationship between other variables such as forage habitat value and distance to urban areas. However, it was also important to identify weekly and seasonal bear abundancen by gender and uniquely identified bears.

Once the DNA hair samples had been examined, it was possible to analyze the data to gain insight into the abundance of bears at snag sites throughout the Resort Municipality of Whistler. The data were separated into applicable tables and then examined through a compilation of Microsoft Excel bar charts and scatter plots. There were however, many methods in which the data could be analyzed when examining bear abundance at snag sites. There are two ways in which I can define and analyze bear abundance; the first includes the number of '**unique**' bears identified at a hair snag site and the second includes the number of '**times**' bears were identified at hair snagging sites. The difference being that during a two-week bait and collection period at one hair snagging site three unique bears may have been identified. However, those bears may have left and returned the following week. If each of the three bears behaved similarly by returning at least once to the same hair snag site, I would conclude that there were three unique individual bears identified at the hair site or, that at the hair snag site bears were identified six times. This could be broken down even further to examine the data by gender, by week and by season. I concluded that examining the data by unique individual bears as well as number of times bears were identified were equally important because they answer different questions. If a bear repeatedly visits the same hair snagging sites week after week I have a better understanding of that particular bears home range size and habitat use, while examining the number of unique bears at one hair snagging sites may give me more insight into travel routes and corridors.

More explicitly, I was able to examine the number of times each unique bear was identified, at what hair snagging sites, and during what week or what season. From this data I was able to spatially analyze individual bears movements. This is clearly not as accurate as radio telemetry but it does provide managers with more understanding of bear movements throughout the RMOW and within the vicinity of the hair snag stations. To achieve this, I created a list that included those bears identified three or more times during the 13-week sampling sessions. Bears identified three times or more were used because they provide more consecutive movement data. Data were plotted by drawing a line from one point to the other, which connected each consecutive hair snag site that unique bears were identified at, however, only data from those bears identified three or more times were included. This data were displayed as an overlay attribute using a TEM data set in ArcView. The final GIS map provided a spatial overview of bear movements by gender, and in areas of the RMOW that was monitored with DNA hair snags. I also ran a distribution analyzes in the statistical program JMP IN 4 to examine the distances between the nearest consecutive hair snagging sites, and the furthest hair snagging sites. I examined this further by separating the data by gender and running another distribution analyzes.

3.3.2 Relationships among seasonal forage habitat values, bear abundance, and distance from urban areas to hair snagging sites

I spatially examined both the forage habitat values derived from field transects and bear abundance at each of the hair snagging sites; however, the question still remained as to whether there was a positive or negative correlation between these two variables. I used a Kolmogorov-Smirnov test of normality to test distribution normality. In each instance, both of these variables were not normally distributed. I chose to perform a non-parametric Spearman's rank correlation to examine the relationship between the abundance of bears and black bear forage habitat value. I broke this down even further, to examine the relationship between forage habitat value and gender. For these analyzes, I define bear abundance as the number of times bears were identified at each of the hair snagging sites. I also performed a non-parametric Spearman's rank correlation to examine the relationship between the above variables with distance from urban areas. To determine if each of these three variables had an effect on each other I ran the data through a ANOVA Fit Least Squares Model by season and gender.

4 RESULTS

4.1 Genetic analyzes

4.1.1 DNA extraction and marker selection power

During 2002 and 2003, 353 hair samples were collected and DNA was extracted to determine individuality of the bear and its gender. The hair samples collected during 2002 were used only to determine a minimum population and the 283 samples collected in 2003 were used for the remaining analyzes. Of the 353 samples, 40 (11%) consisted of samples that produced insufficient data to establish individual identity, 22 (6%) consisted of samples that produced results consistent with a mixture of DNA from two or more individual bears, and 290 (82%) of the remaining samples consisted of black bear samples that produced solid genetic data, allowing them to be assigned to genetically-defined individuals (Table A6).

The amount of material that was available for extraction was high, with 241 of 352 (68%) extracted samples yielding at least four guard hair roots for extraction; a threshold below which success rates drop off rapidly (Paetkau, 2003). The high sample quality was reflected in success rates, which were very high relative to most projects that make use of non-invasively collected hairs (Paetkau, 2004).

The variability of the available markers was tested to confirm whether there was sufficient information content in these markers to address the questions at hand. There were 12 markers identified by referring data from other parts of B.C. Fifteen samples were selected to test the markers. Five markers stood as exceptionally variable in these preliminary results. Due to the small sample size, further marker selection was necessary until there was enough data from 20 individuals. The project was completed using six markers. The level of variability in this study population was high, with observed heterozygosity averaging 80% across the six most-variable markers for the total number of individuals in the combined results file. Paetkau (2003) suggests that DNA-based marker-recapture studies can make use of five-locus marker systems when the heterozygosity of those markers is 78% or higher (Table A6). My results far exceeded those standards.

4.1.2 Identification of individuals and gender analysis

Once the genotypes were completed and checked for errors, a computer search for identical genotypes was performed and individuals were defined for each unique genotype. Starting with 290 samples that had good genotypes, 59 individual bears were defined. Analyzes of gender was based on a size polymorphism in the amelogenin gene. From this criterion, it was possible to generate strong, clear, gender results for all 59 individuals, identifying 29 males and 30 females. However, this number also includes samples collected during 2002. Therfore, I reviewed the results to determine which bears were only identified in set "A" which was from 2002; the end result was that nine of the 59 unique bears were only identified during set "A" which means that 50 bears were identified during the 2003 summer and fall 13 week sampling session. Of those nine bears, eight of them were male and one was a female, therefore, 29 females and 21 males were identified during the 2003 summer/fall sampling sessions.

4.1.3 Genotyping errors

The 290 samples that were assigned to individuals in this file, 274 (94%) produced a genotype that was observed in at least one other sample. This is strong evidence of data reproducibility. The very observation of an identical multilocus genotype in two different samples, argues that the genotype in question is correct. In effect, errors are not expected to be reproducible, so replication *per se* is evidence of accuracy. After the data were subjected to data scrutiny and replication it was very unlikely that the number of individuals in the file has been overestimated through inconsistent genotyping of different samples from the same individual (Paetkau, 2003).

4.2 Patterns of bear abundance at DNA hair snagging sitesping sites

4.2.1 Spatial distribution of unique black bears

During the 2003 DNA hair sampling session, 50 black bears were identified in the Resort Municipality of Whistler. However, because of the unevenly distributed urban development, Whistler Blackcomb ski hills, Highway 99, golf courses and natural forage, the numbers of bears identified at hair snag stations were not equal (Table 2). The area with the highest numbers of identified unique bears was at a hair snagging site located just a few 100 vertical meters above the Olympic Gondola station, which, borders both the CWHms1 and MHmm1 zone; there were seven unique bears identified at this hair snagging sites site (Figure 6), four females and three males (Figures 7 and 8). Just 500 vertical meters above that hair snagging site, past Emerald Chair, another 6 unique bears were identified. This also occurred in the south-western side of the wizard zone on Blackcomb Mountain. In each of these two locations, four females and two males were identified. Back on Whistler Mountain, only 100m above the Olympic Station another 5 unique bears were identified, three females and two males. The largest number of unique bears identified, was on Blackcomb and Whistler Mountains. There were 26 unique bears identified on both Whistler and Blackcomb mountains at 13 hair snagging sites, with nine on Whistler Mountain and four on Blackcomb Mountain. Of the 26 unique bears identified on Whistler and Blackcomb Mountains, 14 of them were females and 12 of them were males. There were at least two unique bears identified at each hair snag on the mountain, however, four or more were identified at nine of the thirteen.

A relatively large number of unique bears were identified at hair snagging sites in and around the landfill. In this area, there were four hair snagging sites set up around the perimeter of the landfill and one across the highway at Function Junction. One snag site alone identified 4 unique bears, with a total of eight for all five of the hair snagging sites. Of the eight individuals identified, five were female and three were male.

The other hair snagging sites, which also identified high numbers of unique bears, were located between Emerald Estates and Alpine Meadows that are adjacent to Highway 99, and Green Lake, Emerald Forest, and Nickalus North Golf Course. At both of these hair snagging sites, four unique bears were identified, each identifying three males and one female.

There was a general trend in abundance of uniquely identified female black bears in the Resort Municipality of Whistler. The highest number of identified unique females at one hair snagging site was four. This occurred at three snagging sites, two of which were on Whistler Mountain and the other on Blackcomb Mountain. Two unique female bears were only ever identified at hair snagging sites within the valley bottom and within very close proximity to urban areas. Meanwhile the number of unique male bears identified on Whistler and Blackcomb Mountains was the same as the number of male bears identified in other areas of the RMOW. The highest number of unique male bears identified at one hair snagging sites was three. This occurred at two hair snagging sites on Whistler Mountain, once at a hair snagging sites between Emerald Estates and Alpine Meadows adjacent to highway 99 and Green Lake, and again in Emerald Forest adjacent to the Nickalus North Golf Course.

4.2.2 Seasonal and weekly patterns in bear abundance

Seasonal bear abundance

The approach to sampling with 48 hair snagging sites in an approximately 20 km^2 area, resulted in a high number of individual bears identified during the 2003 hair snagging sessions. The summer sampling session was conducted between July 3, 2003 and August 4, 2003, and the fall sampling session was conducted between August 19, 2003 and November 11, 2003. During both sampling sessions 45 unique bears were identified. Of the 45 individual bears 76% (34/45) were identified in the summer sampling session, and 53% (24/45) were identified in the fall sampling session (Table 3). Twentynine percent (23/45) of the total individual bears identified, were identified during both the 2003 summer and fall hair sampling sessions. However, during the month prior to the commencement of the summer sampling session and between the summer and fall sampling sessions, hair samples were collected for the purpose of determining a minimum population. During this time, there were five more bears identified with a total of 50 identified individual bears for 2003.

Bear abundance and seasonal re-identification

It was also common to have a bear identified multiply times throughout both of the sampling sessions. As a result, black bears were actually identified at hair snagging sites 143 times (Table 3) (Figure 9). This is not referring to the number of unique bears identified in RMOW but the number of times a bear was identified at one hair snagging sites for each of the weeks in the two sampling sessions. I examined the total number of male and female bears identified each week at hair snagging sites for both sampling session and found the total number of times male bears were identified during both sampling sessions accounted for 46/143 (32%) where as females accounted for 97/143 (68%), (Table 4). Of the 143 times that bears were identified at hair snagging sites, I found that 87/143 (61%) were identified during the summer session, where as 39% (56/143) of the identified samples were from the fall session (Table 3). The sampling session had a 15% higher effort rate then the summer session. Moreover, there was also a noticeable difference in identified samples between the female and males. In the summer session, 63/87 (72%) of the identified samples were female and 24/87 (28%) were male where as 34/56 (61%) were female and 22/56 (39%) were male in the fall (Table 4), (Figure 9).

Weekly bear abundance

I examined the number of unique bears identified at hair snagging sites each week assuming each bear could only be identified once each week. By examining weekly bear abundance, I gained more insight into weekly abundance at hair snagging sites during both the summer and fall sampling sessions.

I further examined the total number of unique bears identified by gender. Assuming that each bear was identified only once per week, there was a total of n=116 bears identified during the summer and fall sampling sessions; however, the total increased to 143 when including bear repeats at hair snagging site (Figure 10).

During the first week of the study July 3, 2003 ten unique bears were identified. During the following two weeks it decreased by almost half. By the fourth week of the study during late July, there were 22 unique bears identified, which was the highest number of bears identified during the summer and fall field seasons. During the following weeks, the number of unique bears identified decreased yet still remained high with 12 bears identified each week thereafter. Although there were only individual bears identified during the fifth week, bears were identified at different hair snagging sites 24 times (Figure 10).

I examined the number of female and male bears identified each week, however this included bears identified multiple times each week. Throughout the summer session excluding the second week in July more females were identified than males. The highest numbers of females identified was in the fourth week where 15 females and seven males were identified. Following this peak, there was a slight reduction in bear abundance for the fifth and sixth week of sampling. It did however, remain high with the identification of 9 and 10 female bears and 6 and 3 male bears respectively. During the six-week summer study and taking into consideration those bears identified multiple times, a total of 49 females and 24 males were identified (Figure 11).

The number of unique black bears identified during the fall months was much less then the summer session. The number of bears identified in the fall peaked during the third and fourth week of the study, which was the first few weeks in September. Thereafter, the number of unique bears declined to as low as two bears in the last week of October. This number slightly increased to four bears by early November. The abundance of bears or the number of times bears were identified at hair snagging sites had a similar pattern to the unique bears identified. During the first few weeks of the fall study, black bears were identified 11 times. This number decreased thereafter, to as low as four by the last week of October (Figure 12).

Throughout the fall sampling session, excluding the second week of the study more females were identified than males. The highest number of identified female bears during the fall sampling session was six during the third and fourth week, and the number of identified males was five, which occurred in the second week. During the sixth week of the fall sampling session, no male bears were identified. During the seventh week, three females and one male bear were identified (Figure 13).

4.3 Bear abundance and movement across the landscape

4.3.1 Re-identification of unique bears during the summer and fall sampling sessions

I found that 36% (n=16) of the 45 unique bears identified during the summer and fall sampling study were only identified once, whereas 64% (n=29) were identified at hair snags two or more times which included bears identified at different hair snagging sites during the same week (Table 5). The number of times bears were identified fluctuated by season; bears were identified during either the summer and or fall sampling sessions. One bear in particular was identified 12 times across both sampling seasons and another bear was identified 10 times. Of the total number of unique bears identified over both sampling periods, 64% were identified two or more times. See Figures 14 and 15 for a summary of the number of times each bear was identified during the summer and fall sampling sessions.

4.3.2 Re-identification of unique bears at multiple hair snagging sites during the same week

I found that an individual bear could be identified at multiple hair snagging sites during the same sampling week. During the summer and fall sampling sessions, 16 bears visited multiple hair snagging sites in one week; 10 were in the summer (seven females and three males) and six were in the fall (three females and three males) (Table 6). This reveals that 63% of bears identified two or more times in the same sampling week were females. Of the 16 bears, 14 were identified as unique bears; hence 31% (14/45) of unique bears identified during both sampling sessions were identified at two or more hair snagging sites during the same week. However, there were six occasions where five unique bears were identified three times at different hair snags in the same week.

4.3.3 Re-identification of unique bears at a single hair snagging sites site

To gain more insight into bear distribution and home ranges, I identified the number of times an individual bear was identified at the same hair snagging sites. The highest number of times a bear was identified at the same hair snagging sites was 9 (n=1), however, 59% (n= 27) were only identified at the same hair snagging sites once (Table 7). Females had a higher tendency to be identified repeatedly at the same hair snagging sites than males. During the summer and fall sampling sessions 44% (12/27) of females were only identified at the same hair snag site once compared with males, where 77% (17/22) were only identified once. Female bears were also identified repeatedly at the same hair snagging site a maximum of nine times compared with males who were identified a maximum of four times at the same hair snagging site.

As stated in the latter sections, many of the bears identified during the DNA hair snagging sessions, were identified multiple times. Subsequently, I was able to plot a line, using Arview GIS, from each consecutive hair snagging site in which a bear was identified. I conducted this for both female and male bears, which provides more insight into the areas in which unique bears were located (Figures 16 and 17).

4.3.4 Distance travelled between the approximate and furthest hair snagging sites

Determining a bear's home ranges and movement patterns are complex processes, and require large amounts of data, usually acquired through radio telemetry. However, because many of the bears in The Resort Municipality of Whistler were identified multiple times and as high as thirteen times, I was able to examine some of the areas and distances that individual bears moved. To obtain this information I examined all bears that were identified three or more times. I also determined the largest distance from where the bears were identified to the next consecutive hair snagging sites as well as the furthest non-consecutive hair snagging sites for both female and males. These data however, are constrained by the size and placement of my hair snagging sites. As a result, bears could have easily moved beyond the hair snagging area, hence movements are likely underestimated.

Female

Five of the 16 female bears that were identified multiple times during both the summer and fall sampling periods were identified multiple times and often at the same hair snagging sites. One female bear in particular was identified nine times at the same hair snagging sites all of which occurred in different weeks. I therefore conducted two different analyzes to examine the mean distances for female bears. The first analysis included those bears identified at the same hair snagging sites with distances equal to zero. I excluded them in the second analysis (Table 8). With n=16, the maximum distance between hair snagging sites that the bears were identified at was 5082 m, with a mean equal to 2072 m and the median equal to 2156 m. The standard deviation was 1768.3m with a standard error mean of 442 m. The second analysis with n=11, the maximum distance between hair snagging sites was 5082 m and the minimum was 809 m with a median of 2437 m. The mean was equal to 2541 m with a standard deviation of 1124 m and a standard error mean of 339 m.

To better understand the distance that encompass the bears home ranges, I calculated the furthest straight line distance travelled from one hair snagging sites to the other but not necessarily consecutively (Table 8). As indicated in the adjacent section two statistical analyzes were conducted, the first which included bears identified multiple times at the same hair snagging sites, and the second which excluded them. When n=11, the furthest distance travelled was 5082 m with a median of 3390 m and a mean of 3014 m. The standard deviation was 1326 m and the standard error mean was 400 m. There was a significant decrease in distance when I included those bears identified at the same hair snagging sites. With n=16, the median decreased to 2156 m with a mean of 2072 m and the standard deviation and standard error mean increased to 1804 m and 451 m respectively.

Male

One of the six bears identified multiple times during the summer and fall sampling sessions was identified four times at the same hair snagging sites. I therefore conducted two different analyzes to examine the mean distances of male bears. The first analysis included the bear, which had been identified multiple times at the same hair snagging sites with a distance of zero, and the second analysis excluded it (Table 8). I found with n=5, the maximum distance travelled to the approximate hair snagging sites was 5907 m and the minimum was 2295 m with a median of 5235 m. The mean was 4829.4 m with a standard deviation 1464 m and a standard error mean of 655 m. When I examined the distance to the approximate hair snagging sites with n=6, the minimum distance was zero with a decrease in the median 5109 m and mean 4024 m. The standard deviation was 2367 m with a standard error mean of 966 m.

For males, I calculated the furthest straight-line distance travelled from one hair snagging sites to the other but not necessarily consecutively (Table 8). As indicated in the above section two statistical analyzes were conducted; the first which excluded the bear which was identified multiple times at the same hair snagging sites and the second which included this bear. When n=5, the furthest distance travelled was 6601 m with a median of 6162 m and a mean of 5434 m. The standard deviation was 1773 m with a standard error mean of 793 m. There was a significant decrease in distance when I included the one bear identified multiple times at one hair snagging sites. With n=6, the median decreased to 6034 m with a mean of 4528 m. The standard deviation and standard error mean increased to 2727 m and 1113 m, respectively.

4.4 Seasonal forage use

4.4.1 Feeding patterns

Black bears are one of the largest terrestrial omnivores in North America, consuming a variety of vegetation, insects, and animal matter (Holcroft and Herrero 1991; Gaines 2001; Bull et al. 2001). Black bears are usually faced with seasonal changes in both abundance and nutritional quality of food and thus have had to develop new ways to adapt to these changing food resources (Powell et al. 1997). An example of such an adaptation is the use of anthropogenic food sources found in areas such as garbage dumps, campsites, residential neighbourhoods, and roadsides (Powell 1997; Gaines 2001). Black bears are highly opportunistic and extremely mobile (Vander Heyden and Meslow, 1999), hence, they have developed the necessary traits to locate food sources in an environment in which food sources vary both temporarily and spatially (Vander Heyden and Meslow, 1999). Because food resources become both isolated and fluctuate from season to season black bears have had to diversify their selection strategies based on the composition and availability of habitats within each bear's home range. It has become crucial in effective black bear management to have knowledge of their habitat needs, including seasonal foraging areas, denning, and security cover. Because diet studies and habitat research have not been published for the Whistler area I used information from other regions.

Changes in the seasonal use of plant and animal foods by black bears is common and are shown to vary with the availability, distribution and abundance of preferred foods (Herro 2002; Stamp 2003). Black bears eat a wide range of food that varies by month and ecosystem and are quite selective in what they consume. Food habit studies provide valuable information about the seasonal importance of different habitats for black bears. Nonetheless, because much of black bear food preferences are local in scope, there have been sufficient habitat use studies conducted in western North America to indicate consistent habitat use trends during spring, summer and fall at a broad level.

4.4.2 Spring food

During the first two to four weeks after den emergence black bears primarily forage in areas where preferred plants are in early growth stage (Grant 1989; McCrory 1998; Noble and Meslow 1998; Gaines 2001; Stamp 2003). Earlier phenological stages are selected, as during this stage of growth the leaves, stems and shoots of most herbaceous plants and a few shrubs and trees are succulent, easily digested, and high in nutrients compared to later growth stages when flowering, fruiting, or dormancy has occurred (Herrero 1985; Holcroft and Herrero 1991). Moreover, during the spring, plant foods are higher in protein and lower in fiber than later in the year (Mealey 1980; Herrero 2002; Noble 1998; Bull 2001) and bears are only 5% less efficient at extracting plant protein than ruminants (Prichard and Robbins, 1990). In some systems, where available, bears may complement spring vegetation with carbohydrate or fat rich foods. In other regions such as Minnesota (Ternent 1995; Rogers et al. 1988) bears had access to abundant over wintered acorns, while grizzly bears in Yellowstone National Park (Mealey 1980; Mattson et al. 1991) continued to feed on clover throughout the summer, thus suggesting that vegetation was an important dietary component. The protein found in vegetation is believed to complement the energy rich summer diet of berries. However, Brody and Pelton (1988) found a decline in the vegetation consumption during the fall as digestion shifts to favor fat and carbohydrate assimilation and metabolism favors fat deposition (Nelson et al. 1993).

Each system varies in available spring food sources, however, there are common species found in each of the studies examined that suggest that they are a crucial component of a bears diet. Most studies have found grasses, sedges and horsetail to be primary spring and early summer foods, and in some areas, used through the fall where succulent (Grenfell and Brody 1983; Smith 1984; McCrory 1998; Stamp 2003; Volker 2004; McCrory 2004). However, more specifically, some British Columbia studies have found the dominant spring food species to include Skunk Cabbage(*Lysichiton americanum*), lady fern (*Athyrium filix-femina*) , clover (*Trifolium spp.*), dandelion (*Taraxscum officinsle*), and devils club (*Oplopanax horridus*). In lower elevation and costal ecosystems some berry producing species such as red elderberry (*Sambucas racemosa*), salmonberry (*Rubus spectabilis*), and thimbleberry (*Rubus parviflorum*) ripen earlier and may also be frequently consumed. The bearberry *(Arctostaphylos uva-ursi*), which is high in carbohydrates, is a very important and extensively used spring food. Fruit of the bearberry usually stay on the plants throughout the winter and are therefore readily available for bears upon den emergence. During the winter months over-winter berries increase their sucrose content (Herrero, 2002) and in some ecosystems make up to 50% of the spring diet (Machutchon, 1989). Many studies conducted in British Columbia also noted a relatively high consumption of bearberries upon den emergence. Black bears in Nahanni National Park have also been observed eating a bear berry (*Arcto, taphylos rubra)* during the spring months, while Smith (1984) and Stelmock (1981) found that black bears in the northwest coast and the Yukon eat over-wintered low bush cranberries (*Vaccinium*) along with over-wintered crowberries (*Empetrum nigrum*). The evidence therefore suggests, that over-winter berries are a larger component of the bears diet for coastal and northern black bear. This may be the case because other herbaceous vegetation has not yet emerged and grasses and other vernal growth does not occur until later in the season.

Complementary to the extensively consumed grasses and sedges Reynolds and Beecham (1980), also found that herbaceous dicots have also been primary food sources in spring and early summer. In Oregon during the spring season, devils club and *Rubus spp.* were the only shrubs identified from scats in two studies (Noble and Mezlo, 1998). McCrory found in many southern B.C studies horsetail (*Equisetum arvensus*) was also a delicacy for bears and was extensively consumed wherever available. Scat studies conducted on bears in the Yukon found that horsetail accounted for the greatest percent volume (Machutchon, 1989). Holcroft and Herrero (1991) found that *Equisetum arvense* and *E. pratense* were the main species of horsetail encountered in scats during spring in Alberta however, they were secondary in importance to other herbaceous matter. During spring, black bears will also feed opportunistically on winter-killed, winter-weakened, or road-killed ungulates. They are also adept at preying on newborn young of ungulates (Table 9).

4.4.3 Summer food

Black bears are non-cecal monogastric animals, meaning they cannot digest fiber efficiently, and hence cannot increase their fat stores on foliage alone. Small wild berries play a crucial role in summer and early fall food for bears. Berries are high in carbohydrates and help to provide bears with the necessary energy reserves for reproduction and winter hibernation. This is especially the case in areas where energy dense foods such as salmon are scarce or unavailable (Welch et al, 1997). Some of the more common berries consumed by bears along the coast and interior of British Columbia interior mountains are huckleberry, blueberry, soopolallie, bitter cherry, thimbleberry, crow berry, devils club, red-osier dogwood, current, Oregon grape (*Berberis repens*), rose, bearberry (*Arctosphylos uva-ursi*), red elderberry, salmonberry, black twinberry, mountain ash, salal (McCrory 1998, 2002, 2004). In areas such as Oregon, Bull et al. (2001) found that the largest amount of fruit consumption in the mid to late summer months and into early fall. The more common berries consumed during this study were bearberry (*Arctosphylos uva-ursi*) and hawthorn (*Cratagaegus spp.*) bug huckleberry *(Vaccinium membranaceum*, swamp gooseberry (*Ribes lacustre*), raspberry (*Ribes ibaeus*), grouse huckleberry (*V. scoparium*), mountain snowberry (*Symphoricarpos oreophilius*) strawberry (*Fragaria spp.*), dogwood (*Cornus canadensis*), bitter nightshade (*Solanum dulcamara*), Nootka rose (*Rosa nutkana)*, creeping Oregon grape (*Berberis repens*), bearberry, honeysuckle (*Lonicera involucata*), and buffaloberry (*Sheherdia pumila*). There was also a similar trend among northern studies such as the Yukon and Alaska the more commonly consumed berries were soapberries (*Sherperdia ucanadiensis*), blueberries (*Vaccinium caespitosum*), bog cranberries (*Oxycoccus oxycoccos*), and occasionally crow berries (*Empetrum nigrum*) (Machutchon, 1989).

Although berries and some vegetation are common food source for bears during the summer months, cambium and insects also play a crucial part of a bears diet, especially during a low berry crop or drought. A study conducted on the central coast of

Oregon found that bear scats from an area with low levels of tree damage by bears contained significantly more berries than did scats from an area with high levels of damage (Noble, 1998). It is often common to see a higher frequency of cambium in scat during late spring to early summer as this is when trees experience a higher level of moisture stress (Noble, 1998).

During summer months, and especially during a berry crop drought, insects can provide bears with an important source of protein and fat (Rogers, 1987). Ants (Formicidae) and yellow jackets (Vepsidae) are usually the most important insect food and have the highest consumption rate during summer and fall depending on the berry crop (Holcroft and Herrero 1991; Bull et al. 2001). Foraging on ants by ripping and turning over logs requires a large expenditure of energy than more readily available food resources, and therefore, may be reserved for times when other more readily available foods are in short supply (Bull et al. 2001). Weather changes from year to year may also play a role in the different frequencies and volume of consumption (Lloyd and Fleck 1978; Bull et al. 2001). In Northern Oregon, July scats had significantly more insects than any other month, while scats collected in August September, and October had significantly more insects than those in May and June (Bull et al. 2001). However, in southwest Alberta, ant consumption was not significantly different among seasons, but received highest use in early summer and lowest use in spring and fall. Furthermore, other studies have found ants to occur in low volumes but high frequencies in spring scats and higher volumes in mid summer scats (Lloyd and Fleck 1977; Smith 1984; Irwin and Hammond 1985). In the Yukon, MacHutchon (1989) found ants to be the most frequent animal food during June and July months, similar trends have been reported elsewhere

(Tisch 1961; Halter 1972; Nagy and Russell 1978). Females with cubs and sub adults were also found to have a higher volume of ants in their scat than females without cubs (Bull et al. 2001). Along with the consumption of insects comes the consumption of debris. Debris usually consists of a variety of items including gravel, soil, conifer needles, cones, decayed leaves, and wood chips (Holcroft and Herrero, 1991). Usually the items are ingested accidentally given its poor or non-existent nutritional value (Herrero 1985; Holcroft and Herrero 1991; Bull et al. 2001); (Table 10).

4.4.4 Fall food

By fall, plants begin to approach dormancy and for many areas, especially northwestern America nutrients are once again transferred underground to the root system. Depending on availability, bears will spend what time they have until the ground freezes eating berries or where it is available, spawning salmon (Holcroft and Herrero 1991; Welch et al. 1997; Bull et al. 2001; Gaines 2001; Stamp 2003). Some of the more commonly consumed berries in the fall include buffaloberry, wild red raspberry, bearberry, huckleberry, and prickly rose (Unsworth et al. 1989; Clark et al. 1994; Bull et al. 2001; Lyons et al. 2003; McCrory 2004). Several other fruits were consumed during the fall months but at low volumes such as the Saskatoonberry (*Amelanchier alnifolia*), twisted stalk *(Steptopus amplexifolius*) and honeysuckle (*Lonicera involucrate*) (Holcroft and Herrero, 1991). Location and weather may play an important role in fall found sources due to earlier ripening and snow cover. In areas where the ground freezes in early fall insects and animal remains may provide a critical source of protein for bears (Holcroft and Herrero, 1991). One of the more commonly consumed insects in the fall is the yellowjacket (*V. vulgaris and V. pensylvanica*) (Bull et al, 2001) which are both logdwelling species (Akre et al. 1980; Bull et al, 2001). Lloyd (1979) observed feeding on yellowjackets in only the second of his two year study in coastal British Columbia, while a study in Montana yellowjackets were consumed in the summer and less frequently in the fall (Tisch, 1961). Other insects are occasionally consumed but to a lesser degree, these include both the grasshopper (*Acrididae*) and bees (Holcroft and Herrero, 1991). Mammal remains seem to be generally low and vary from study to study. However, it was evident in some studies that mammal remains were more commonly consumed during the fall months. This is most likely the case, because other more desired food sources are less abundant or unavailable. Lastly, in many coastal and interior ecosystems salmon have been an extremely important part of a bear's intake. Salmon spawn at different times of the year depending on the species and the location. It is therefore difficult to summarize precisely what month of the year you would expect to find bears gorging themselves on salmon (Table 11).

4.5 Habitat values for buffered hair snagging sites locations using coarse and fine scale evaluations

4.5.1 Seasonal forage habitat values derived from Terrestrial Ecosystem Mapping (TEM)

I used site series as the biogeocimatic classification system to determine forage habitat values at hair snagging sites locations. As noted previously, four different biogeoclimatic zones fall within the Resort Municipality boundaries CWHmsw1, MHmm2, MHmmp2 and ATc (Figure 3). However, the DNA hair snagging sites locations were only placed in the CWHmsw1 and MHmm2 (Figure 5). Additional site series classifications were added when the TEM mapping was conducted; therefore I calculated the total percent cover for the buffered hair snagging sites locations to determine the additional site series categories within the CWHmsw1 and MHmm2 zones (Table 12). There were 30 categories in the CWHmsw1 zone and 12 in the MHmm2 zone. I then calculated the total percent cover within the buffered hair snagging sites locations for each of the site series classifications for both biogeoclimatic zones (Figure A7). I found that of those 30 site series classifications found in the CWHmsw1 zone, 75% consisted of the following site series categories: 35% was site series (01), 19% was (03), 14% was (04), and 12% (UR). Of the 12 classifications for the MHmm2 zone, 95% consisted of the following site series categories: 58% was site series (01), 32% was (sk) and 3% was (02). The percent cover for each site series classifications within the CWHmsw1 and MHmm2 zones were calculated again for each individual hair snag site, which was then used to determine forage habitat values at each hair snagging sites location (Table A1).

Within the site classification system, site series encompass sites capable of producing similar late seral or climax plant communities within the biogeoclimatic zone subzone or variant. Sites with similar vegetation potential have similar environmental properties, particularly soil moisture and soil nutrient regimes. Because the site series classification system uses soil moisture and nutrient regimes, I was able to deduce which of the preferred bear forage species would be found in each site series class. I created a preferred bear forage list, which I was able to use along with the soil moisture, and nutrient regimes to create bear forage habitat values for each of the hair snagging sites locations (Table 13). There were particular high value bear foods that I used as important deciding factors, however not exclusively, for determining the seasonal habitat values.

For spring, the preferred spring foods consist of grasses and sedges, lady fern (*Athyrium filix-femina*), clover, bearberry (*Arctostaphylos uva-urs*), skunk cabbage (*Lysichiton americanum*), common horsetail (*Equisetum arvense*), and overwintered bearberry (*Arctostapphylos uva-ursi*). For late spring and early summer, I found that early ripening berries such as red elderberry (*Sambucas racemosa*), salmonberry (*Rubus spectabilis*), and thimbleberry (*Rubus parviflorum*), and for middle to late summer, red and black huckleberry (*Vaccinium parvifolium, membranaceum*), wild red raspberry (R*ubus idaeus*), blueberries (*Vaccinium alaskaense*), mountain ash (*Sorbus scopulina*), bearberry and salal (*Gaultheria shallon*) were preferred. For the early fall months, bearberry, devils club (*Oplopanax*), rosehip (*Rosa*), mountain ash (*sorbus*), huckleberry (*Vaccinium*), red osier dogwood (*Cornus stolonifera*) and grasses were consumed (Wayne McCrory, personal communication, 2005).

Based on these data, I assigned a seasonal bear forage habitat value to each of the site series classifications found within the CWHmsw1 zone and MHmm2 zone. I multiplied it by its percent cover, resulting in the seasonal forage habitat value for each hair snag site in Whistler (Tables A2 and A3).

4.5.2 Seasonal forage habitat values derived from ground transects

During the summer of 2005, I conducted habitat transects for each of the buffered hair snagging sites locations to determine forage habitat quality using a finer scale method. A table was constructed which indicated the total percent cover of each of the bear forage species and is detailed in (Table A4). The percent cover enabled me to apply a habitat value based on a five-point scale of very high to very low. From this I was able to apply a more accurate habitat forage value than the method described above for each of the buffered hair snagging sites locations (Table A5).

4.5.3 Examining the relationship among habitat rating

Conducting field transects is a more accurate method of developing habitat values (McCrory, personal communication, 2005), however this type of fieldwork can be time consuming and costly. I therefore compared the use of TEM mapping and ground transect as methods for developing forage habitat value (Table 19). I used a nonparametric Spearman's rank correlation in the program JMP. I found a significant positive correlation between the two methods for both seasons with Rho=0.5, and P=0.001 for summer and Rho=0.44, and p=0.004 for fall. This analysis demonstrates that there is a significant correlation between the two methods, however, for the following analysis where I used forage habitat values and abundance, I choose to use the habitat value results from the ground transects (Table 14).

4.5.4 Frequency of forage habitat values

The black bear habitat forage value for the Resort Municipality of Whistler was created from a series of ground transects conducted in the field which was based on black bear preferred and occasionally used forage plant species. To gain more insight into seasonal habitat forage value patterns the values were analyzed using the program JMP to examine the general distribution of values based on a scale ranging from very low, low, moderate, high and very high for all of the buffered hair taps within the RMOW. The median for habitat values for spring summer and fall were moderate (3=moderate). The mean habitat values were moderate for both spring and summer and between low and moderate for fall. There was a noticeable trend of low quality habitat values in the spring and fall where 12 hair sites values for spring and 11 hair sites values for fall were (low). However, spring also had 13 (very high) hair sites values, which was the largest among each of the seasons. The summer habitat values were more normally distributed with 19 (moderate) hair site values and 15 (high habitat) values (Table 15).

4.5.5 Spatial seasonal forage habitat values

For the frequency of forage habitat values to be more advantageous for managers, I examined the data spatially using the program ArcView. I divided the RMOW study area into 5 categories: Whistler and Blackcomb Mountain; Lost Lake and Chateau Whistler golf course; Whistler Landfill and function junction, Alta lake road; Highway 99; and Whistler and Nicolas North golf courses. The forage habitat value for each of these areas was spatially examined for spring, summer, and fall (Figures 18, 19 and 20).

Whistler and Blackcomb Mountain

Green up begins in early spring in the valley bottom in the CWHms1 and towards mid spring green begins to move up from the valley bottom throughout the lower ski hills. Green up will vary from year to year but the lower ski hills on average year would have green vegetation such as horsetail, clover, grasses and sedges. The spring habitat for the lower part of Whistler and Blackcomb Mountains have a very high black bear habitat forage value. However, a very high habitat value in the spring does mean that the forage abundance in a very high summer value are equal; as the habitat values are based on the normal expected forage abundance for the given biogeoclimatic zone. The hair snagging sites that are near or bordering the MHmm2 zone have moderate to low forage values depending on the year. During early summer the forage habitat value increased further up the mountain and by late summer early fall the hair snagging sites which are in the MHmm2 zone or bordering the MHmmp2 have very high habitat values as the berries ripen. This high value habitat may continue on into fall if there is a late green up. During mid summer the lower elevation habitat on Whistler and Blackomb Mountains become moderate and by fall moderate to low. The ski runs on both Whistler and Blackcomb Mounatains provide and above average forage habitat for bears, as gladded runs such as Greenacres, Bear Cub and Crystal have enhanced huckleberry value along with clover planted on many of the ski runs on both mountains. In addition, grasses, sedges and horsetail are common.

Lost lake and Chateau Whistler Golf Course

Lost Lake and nearby areas provide high to very high forage habitat during the spring months. North west of Lost Lake lies a smaller pond surrounded by a number of grasses, sedges, and in later spring skunk cabbage. Along the western side of Lost Lake lies a steep rocky hillside, which drops down into the White Gold area. Scattered across this ridge is an abundance of bearberry, which in 2005, contained a high number of over-wintered bearberries along with black huckleberry. Surrounded by bearberry and green vegetation Lost Lake provided an abundance of natural spring vegetation. The Chateau Whistler Golf Course, which is on the east side of Lost Lake, also provides an abundance of spring vegetation and security cover. During the summer months the understory in some of the rock and forested areas there is a moderate berry cover mostly consisting of blueberry and black huckleberry, however by late summer and early fall the habitat value is low to moderate.

Highway 99, Whistler & Nicolas North Golf Course

The distribution of forage habitat values of hair snagging sites near Highway 99 vary from very low to very high during the springtime. Only one hair snagging sites had a very high habitat value, which is located in an old growth patch of western hemlock adjacent to Highway 99 and the Nicholas North Golf Course. This patch of old growth contains moderate density abundance of horsetail and grasses while the golf course also provides an abundance of green vegetation. The nearby river of golden dreams also provides an abundance of green vegetation for the spring months. Other areas of high bear forage habitat values are, the pond and wet land behind the Nesters building complex, between the west end of Alta Lake surrounded and the Alta Vista subdivision, and above the bay shores subdivision. These three areas have very moist soil regime and therefore host an abundance of springtime food such as grasses and sedges in early spring and devils club and skunk cabbage in later spring. The remainder of the hair snagging sites adjacent to Highway 99 have moderate habitat values for spring and become increasingly low during summer and fall. The Blueberry Hill Ridge, which consists of mostly second growth forest, contains little to no plant understory. This area remains low habitat value for spring summer and fall.

Alta Lake Road

There are six hair snagging sites located along either side of Alta Lake road. During spring, this area has relatively low to very low quality forage habitat during the spring.

However, on of the hair snagging sites on the north end of Alta Lake where the lake drains into the River of Golden Dreams and meets the Emerald forest the hair snagging sites has a high forage habitat value for spring due to the abundance of horsetail, grasses, sedges, and skunk cabbages found in this area. The two hair snagging sites on the west side of Alta Lake and Nita Lake have high habitat values for summer, this is due to their proximity to the power lines which have high density of huckleberries (V*accinium.*) while the remaining hair snagging sites have low to very low habitat values. The habitat values for the fall only become lower.

Whistler Landfill and Function Junction

The terrain is steep and rocky on the southwest side of the garbage dump and during the spring and fall months the forage habitat is low to very low and becomes moderate during the summer months. This habitat area has more value for its security cover for resting and access to the garbage dump than it does for foraging. The demonstration forest to the east has low densities of Vaccinium. The adjacent hair snagging sites have a slightly higher habitat value, but again the garbage dump offers an unnatural high forage value than the surrounding site. However, Function Junction which is directly north from the garbage dump and across Highway 99 offers high summer habitat due to it proximity to the power lines which in 2005 had an extremely high density of huckleberries and blueberries (*Vaccinium*).

4.6 Relationship between habitat values and bear abundance

4.6.1 Relationship between forage habitat value and bear abundance

I used nonparametric multivariate correlation coefficients to test the relationship between both the habitat values and bear abundance at hair snagging sites, and distance of hair snagging sites from urban areas and bear abundance. The variables that were computed were not normally distributed so I used the Spearman's Rank test because it assumes that the variables under consideration are measured on at least an ordinal (rank order) scale. Both sets of variables were tested independently for summer and fall seasons. There was a positive correlation for both summer and fall between habitat rank and the abundance of bears with Rho = 0.328 and P=0.002 for summer and Rho=0.459 and P=.001 for fall (Table 16). I also used ArcView GIS to display the latter information by overlaying the summer and fall bear abundance at DNA hair snagging sites with the seasonal forage habitat value to provide managers with a spatial view of the correlation between bear abundance and forage value throughout the RMOW (Figures 21 and 22).

To understand the relationship between the derived habitat values at hair snagging sites and the abundance of bears at hair snagging sites, I examined the relationship between these variables at a finer scale using female bears and male bear abundance (Table 16). There was a positive correlation for females with Rho= 0.543 and P=<0.001 for summer and Rho= 0.43 and P= 0.002 for fall. There was no significant correlation between the variables for males (Table 16).

I tested distance of hair snagging sites to urban areas and found a positive correlation between these variables with Rho=0 .46 and P= 0.001 for summer and Rho= 0.40 and P= 0.006 for fall (Table 16). Because there was a correlation between distance and bear abundance, I tested to see if the distance from urban areas was correlated with the habitat ranking. There was a significant positive correlation between these two variables with Rho= 0.5 with P=<0.0001 for summer and Rho= 0.5 and P= 0.0006 for fall (Table 17).

4.6.2 Relationship between forage habitat value, distance from urban areas and bear abundance

To compare the mean values for the variables, bear abundance, distance from urban areas and habitat value rank I used a non parametric ANOVA fit least squares model because the ANOVA allowed me to detect interaction effects between variables and, therefore, to test more complex hypotheses about reality (Table 18). Within this model, I looked at the R^2 value and the analysis of variance for the overall model and the effects test for individual variables. The abundance of bears was tested as the dependent variable and the distance from urban areas and habitat rank were tested as the independent variables. For the overall model I found a positive correlation with R^2=0.22 and Prob< 0.06 for summer, and R^2=0.27 and Prob<0.008 for fall. However, the abundance of bears at each hair snagging sites location was found to be independent P=0.16 for summer and P=0.82 for fall and for distance from urban areas for summer P=0.261 but positively correlated with distance from urban areas for fall with P= 0.01. I found habitat rank to be significantly correlated in the Spearman's test with distance, this may be reason why it was not found to be significantly correlated with the abundance of bears in the effects test (Table 18).

I also tested the interaction effects using the same variables but for both female and males. I found a correlation for the overall model for females with R^2 =0.35 and

P=0.002 for summer and R^2=0.41 and P=0.0001 for fall. I also found that the abundance of bears was dependent on distance to urban areas with P=0.04 for summer and P=0.001 for fall, and for habitat rank for summer with P=0.08 while abundance of bears remained independent of habitat rank for fall with P=0.47. There were no interaction effects between the variables for both summer and fall for male bears (Table 18).

5 DISCUSSION

5.1 Bear abundance in the study area

Black bears are highly opportunistic and extremely mobile animals, necessary traits in an environment in which resources vary both temporally and spatially. There are, however, many factors that influence the use of habitat by black bears, such as cover, denning, slope, edge distance, aspect, elevation, and distance to both roads and urban areas, to name a few. However, one of the most influential factors in habitat selection is forage availability. Consequently, the patchy and fluctuating nature of black bear's food resources leads to diverse selection strategies based on the composition and availability of habitats with each bear's home range. Some consistent trends with bear abundance and habitat use were evident within the RMOW. The DNA hair sampling data provided some insight in spatial trends of bear abundance among the hair snagging sites.

The area with the highest number of identified unique bears was on Whistler and Blackomb Mountains (n=27). This is in part due to the continuous high-density spring and summer preferred foods for black bears. The proximity of cover to feeding areas has also been postulated as influencing habitat selection in several other studies (Novick and Stewart 1982, Grenfell and Brody 1986). Island tree patches and gladded ski runs on both mountains provides a mixture of some open canopy and closed canopy mature timber. Despite the potential for security cover, the closed canopy areas have limited forage use for black bears because many of these stands are extremely dense with little light penetration. As a result, the understory vegetation and bear foods are sparse. The open ski runs, which have been planted with clover, grasses and other sedges, provide black bears with an abundance of spring bear food with nearby closed canopy areas for security. Conversely, the gladded ski runs, which have been selectively logged, create ample light penetration during the summer and early fall, thus, promoting the growth of shrubs and other bear foods such as huckleberries and blueberries. Until last year, the human disturbance on black bears was limited to the lower elevations on Whistler. These disturbances consisted of Hummer and ATV commercial tours, bear viewing tours, and the bike park. However, in 2004, Whistler Mountain opened more terrain for bikers, which provided them with access to over 4800 m of vertical feet of trails. This may influence the use of habitat and bear abundance on Whistler Mountain over the next few years.

The landfill site and Function Junction, where the garbage and recycling depot are located, also exhibited a high abundance of unique bears (n=6). Before 1997, the landfill was open to all wildlife, but mainly used by black bears. The Whistler Bear Task Team estimated that 12-21 bears on average used the landfill each day. Electric fencing was installed around the landfill in 1995 and the number of bears visiting the site decreased. Unfortunately, the bears were persistent and dug holes under the fencing. Attempts were made to eliminate this problem, however, black bears can still be seen foraging inside the fencing today. The number of bears identified at the hair snagging sites around the landfill, indicate that black bears continue to be rewarded with garbage from the landfill. The landfill has reached capacity and by the end of 2005 will be closed down; garbage will be trucked to Washington State. I expect, as a result of this closure, the number of bears in this area will decrease.

A high number of bears identified at the west end of Green Lake and Emerald Forest, may have been a result of the nearby riparian habitat with dense shrub cover and seasonal bear foods. In conjunction with this natural food source, black bears have also received garbage in residential neighbourhoods. Conservation officers have noted this area to be a high problem area with bears and garbage. Wayne McCrory (2003) noted "this area is used as a travel route, with bears periodically accessing human foodstuffs despite a diligent bear-proof program". The Riverside Resort and Campground complex is often visited by bears, and in recent years has had problems with car break-ins and tent invasions. At a hair snagging site in a small pocket of old growth hemlocks, across the highway from the campsite and adjacent to the Nickalus North golf course, we identified three individual bears. There were few bear identification repeats at this hair snagging site, which indicate, that bears use this area as a travel route to get from one side of the valley to the other. Wayne McCrory (personnel communications) observed a large black bear using the railroad underpass under the highway for travel. In conjunction with the moderate to high bear foods, security cover, and garbage found, this will continue to be a high use area for bears in Whistler.

Along the North West side of the valley few bears were identified. The power lines which run parallel with Alta Lake road, provided high value forage habitat for bears during the summer months. Two of the collared bears from the 2005 research study frequent this area (Tony Hamilton, personnel communication, 2005). However, due to a lack of dense seasonal high value habitat, bears continue to move through this area which was indicated by the few repeats of bear identification at the hair snagging sites in the area. I also found that much of the second growth forest along the northwest side of Alta Lake was closed canopy with little light penetration. As a result, there was limited understory vegetation and bear food.

The seasonal bear activity at hair snagging sites was much higher in the summer session than the fall session. During the summer session, the magnitude and dispersion of individual bears was indicative of the food distribution throughout the RMOW. This was noted by the spike in the number of bears identified (n=22) throughout the valley and Whistler Mountain during the third week of July. The overlap in home ranges also coincided with this during the latter part of July. During this time, the breeding season had ended and the forage value was high, resulting in an increased tolerance in overlap by dominant bears.

The activity at hair snagging sites through the fall was much less than in the summer. The number of bears identified during this time was more consistent from week to week with a concentration of bear abundance at higher elevations on Whistler and Blackcomb Mountain. Dissimilarly to the spatial patterns of overlapping home ranges identified during summer, the overlap in fall home ranges were almost exclusive to Whistler and Blackcomb Mountain. Lindzey and Meslow (1977) also noted that the patterns and magnitude of overlap of home ranges varied markedly among seasons. This may be, but not exclusively, a result of concentrated high value forage berry habitat on the mountain and very low to moderate forage berry value in the lower elevations during the fall months.

There are many variables that influence the use of a black bears home range. For example, they can vary greatly depending on the location, season, food availability, density of individuals, sex, and age of the individual. The home range of a male is normally larger than that of a female, and each male's home range will usually overlap the home ranges of several females. Generally, the poorer the habitat, the larger the home range must be to supply the bear with enough food, water, and shelter. Home ranges of bears in Whistler overlapped within and among gender. Jonkel and Cowan (1971) and Polker and Hartwell (1973) considered overlap between home ranges of subadult bears of the opposite sex to be common. However, overlap of home ranges of adults of the same sex, a pattern I observed in Whistler, was considered rare by these authors. The extent of overlapping home ranges was evident in Whistler with the identification of as many as seven bears at one hair snagging sites. This also occurred in other areas throughout the RMOW, but predominantly in the northern end. Overlapping ranges of adult bears of the same sex, undoubtedly reflects a pattern of social organization that has allowed a relatively large number of bears to coexist both on the mountain and in the lower valley (Lindzey and Meslow, 1977). Jonkel and Cowan (1971) found that after break up of family groups, cubs were tolerated in the female home range, and that female cubs occasionally established permanent residency within their mothers' range. The pattern and magnitude of overlap between female bears occurred on Whistler and Blackcomb Mountain exclusively indicating that females seemed to not space themselves out. I believe this pattern remained fairly constant through out the year because of their tendency to use their home ranges in generally the same spatial manner among seasons (Lindzey and Meslow, 1977). Young and Ruff (1982), Pelchat and Ruff (1986), and

Rogers (1987) reported similar observations, that is, shared use of concentrated food sources such as clear cuts or landfills. Rogers (1987) believed that bears did not invest time and energy in securing the exclusive use of concentrated food source, but that a social hierarchy, in which larger and older individuals dominate younger bears, regulates access to resources (Sampson and Huot, 2001), which I believe occur at Whistler. To a lesser extent, the pattern of overlapping home ranges between males does not remain exclusive to Whistler and Blackomb mountains and occurred in other areas of the valley and close to residential areas. The large overlap in home range between bears in Whistler is a direct result of the artificially inflated forage habitat on Whistler and Blackcomb and, in particular for males, the combination of natural foods and Whistler landfill garbage found within the village, residential areas and the garbage dump.

Examining the distances between hair snagging sites where bears were identified provided data on differences in movement distances between female and male home ranges. These distances differed greatly between gender, as the mean distance for males was 4528 meters and 2072 meters for females. The distance that males travel and the territory that encompass their home range, is larger than that for females. The data indicated that this is probably true for Whistler's male bears. There are different reasons for this, one being that in a promiscuous mating system, such as that found in black bears (Rogers 1987; Schenk and Kovacs 1995), parental investment by males is minimal and their reproductive success is limited by the number of females they encounter and with whom they successfully breed. Further dispersal exposes males to a larger number of available female mating partners. Moreover, dispersal by subadult males reduces competition with male relatives for mating opportunities and increases the probability of mating with unrelated females (Waser and Jones, 1983). Females however, may directly benefit from continued use of their mothers range as knowledge of food resources is developed through experiences (Rogers 1987; Mattson 1990) and the predominant energy cost of dispersing for female black bears is probably associated with foraging in unfamiliar areas (Rogers, 1987). Despite the fact that females have overlapping home ranges, philopatry may be a long-term maternal investment strategy that serves to maximize a female's lifetime inclusive fitness (Rogers, 1987). Natal philopatry, is widespread among female mammals and has been documented among female bears in other ecosystems (Lindzey and Meslow 1977; Rogers 1987). To confidently identify natal philopatry in Whistler, further research needs to be conducted to identify relatedness of females with overlapping home ranges.

5.2 Methods for rating forage habitat values

Although human developments have been extensively mapped and studied, no comprehensive bear habitat map has been done for the area despite considerable field research and recent progress on minimizing black bear-human conflicts (McCrory, 2004). The ongoing hazard session, recommends an ecosystem-based approach to future bear management as the best way to integrate the complex situations involving the extensive bear-human interface zone of RMOW. Such an approach, through detailed mapping of bear habitats (and corridors), has been successful in broadening the understanding of bear ecology and bear-human interactions in other areas such as Yoho National Park (Lake O'Hara), south Garibaldi Provincial Park, core areas of Banff National Park and elsewhere. Ecosystem mapping is the framework for applying habitat ratings.

Standardized terrestrial ecosystem classification and inventory methods are employed, to prepare map information from which wildlife interpretations can be derived.

I conducted preliminary habitat forage values, using habitat ratings derived from TEM mapping and field transects. Habitat ratings define the relative importance of various ecological units to wildlife and reflect a habitat's potential to support a particular species by comparing it to the best available for that particular species in the province. Each method provided habitat ratings for the buffered hair snagging sites locations. The purpose of testing the two different methods was to understand the difference in magnitude between the two outputs and to make recommendations on methods for future habitat mapping in Whistler.

The first method I used was Terrestrial Ecosystem Mapping (TEM), which was defined for the purpose of this study as coarse scale mapping. The Terrestrial Ecosystem Mapping methodology integrates the climatic, vegetative, and physical attributes of British Columbia's diverse ecosystems into one map product. The methodology emphasizes the relationship between topographic, terrain and soil features of the landscape, and the vegetation and vegetation development stages of each ecosystem unit. Ecosystem mapping, provides spatial data which can be ecological interpreted to develop forage habitat ratings for black bears. Because the final map is digital, in a geographic information system, the attribute files can be accessed and models developed to display or summarize interpretive information (MWLAP standards for TEM).

Habitat types that were identified as moderate to high value habitat for black bears from the literature were used in conjunction with the site series and site group classifications to develop a habitat rating system for each site series classification within the buffered hair snagging sites locations. Much of the time spent using this method was developing a data set, detailing specific seasonally preferred and occasionally used foods for black bears. Once this data set was compiled, little time was spent translating the data into the TEM site series classification where forage ratings were applied to each site series classification. The final habitat rating output for each of the DNA hair snagging sites was created exclusively with the data provided within TEM mapping. The error was not checked or accounted for by conducting field inspections.

The second method I used to develop habitat values for each of the hair snagging sites was the transect method developed by Hamer and Herrero (1983) and McCrory et al. (1986). Four meter wide strip transects were conducted for each polygon within the buffered hair snagging sites. Along each transect the relative abundance of each important bear food was estimated according to the percent cover described in the result section of this study. Plant phenology and bear signs were also recorded for most hair snagging sites. This method proved to be more time consuming during the field data collection stage then the TEM mapping. However, unlike the TEM mapping method all of the data used to develop the habitat value was collected exclusively through field observations.

When comparing the use of fine scale and coarse scale mapping, I concluded that there was a positive significant correlation between the final two outputs. This indicates that coarse scale mapping such as the use of TEM mapping within the RMOW will have similar results to that of the fine scale mapping. The final results from field observations will always be more accurate but not necessarily more time efficient. The time needed to collect and develop the habitat values using the fine scale far exceeded that needed for the coarse scale habitat values. As a result, I recommend that coarse scale mapping is a sufficient method of determining habitat values. However, as there were still differences in outcome between the results I recommend that ground truthing be carried out in conjunction with the TEM mapping. Bround scale TEM mapping is useful for comparing bear use of different zones while fine scale ground truthing has greater value for such things as evaluating the bear hazard of trails.

5.3 Habitat value, spatial distribution and bear abundance

The distribution of habitat values derived through field transects varied moderately from one season to the other. One of the leading contributing factors to this, is the enhancement and concentration of natural food sources for bears throughout the municipality. The leading factors which contribute to this included the ski hills, golf courses, and electrical power lines. The similarities between these locations include the continued maintenance of grass or shrub-berry sites.

The ski runs on Whistler Blackcomb act like natural avalanche chutes, thus, providing high seasonal forage habitat for black bears. Similar studies have shown that avalanche chutes are an important seasonal habitat for both grizzly and black bears in some parts of their range (Zager et al. 1983; Simpson 1985; Schoen and Beier 1990; MacHutchon et al. 1993; Mace et al. 1996; Munro 1999; McLellan and Hovey 2001). However, unlike avalanche chutes, the ski runs have a maintained habitat forage value from year to year due to the maintenance of grass-forb areas dominated by herbaceous and graminoid vegetation and natural growth of horsetail and reduced and or limited woody vegetation. In addition, many of the ski runs are enhanced with the planting of clover. Typically, due to the exposure of sunlight, the ski runs are often free of snow much earlier in the season, therefore, supporting early green up of several species eaten by black bears. There are also specific areas in the latter part of the summer with a high density of huckleberries (*Vaccinium*) which ripen later in the season providing bears with a longer berry season into early fall.

Furthermore, the adjacent forested areas provide suitable escape for black bears. In habitat surveys, Wayne McCrory (personnel communications, 2005) also found high value huckleberry habitat near tree lines south of Whistler Mountain that was similar to an area in Dimond Head in Garibaldi Park that concentrated use by up to 40 to 60 black bears in the fall. In similar studies of avalanche chutes, research has demonstrated that bears may be displaced even if habitat value is high if the adjacent escape cover is removed (Blanchard 1983; Zager et al. 1983; McLellan 1990). Many of the ski runs on Blackcomb and Whistler Mountain have maintained pockets of forested areas in the center of many ski runs as well as between ski run junctions. This provides bears with access to the high forage values areas while maintaining quick access to the nearby escape cover.

The three golf courses and the main power line in Whistler also provide similar seasonal high value forage habitat for black bears. However, there was a notable difference in values depending on season; powerlines in Whistler provide high value summer berry habitat where golf courses provide high value spring and fall habitat. Golf courses in general, provide a mixture of enhanced grassland and forest habitat that provide bears with a variety of foraging opportunities. As a result of golf courses, the landscape ecology of an area changes due to the conversion of forest to open spaces, and by changing the predator prey. The changes of the landscape by a golf course may, therefore, enhance habitat for black bears by attracting prey species, offering enhanced forage, and by increasing the edge and open space (Alberta Natural Resources Conservation Board, 1992).

In addition to these high value bear forage habitat areas, I found a positive correlation between the habitat value and its distance from urban areas. In other words, the further the habitat was from urban areas the higher the value. The ski hills are a contributing factor to this because much of the seasonal forage value on the ski hills is high. This may also be the case for the power lines, which mainly run on the northwest side of the community and distant to more densely populated urban areas. The power lines at Green Lake cross Highway 99, however, this area, independently of the power lines has high value bear forage habitat. The Whistler Golf Course and the Nicklaus North Golf Course on the other hand, both provide high value bear forage habitat but are directly adjacent to urban areas. For the Whistler Golf Course in particular, a bear has to travel through residential areas or cross the main highway to reach this high value habitat. During my study, it became apparent that there were very few scientific surveys published on the impacts of golf courses on wildlife corridors or habitat use, however many wildlife biologists and researchers provided anecdotal information for specific species. A literature review conducted on golf courses and wildlife by Miistakis Institute (2000) found that a golf course might impact wildlife through habitat alteration, human presence and intolerance, displacement, interspecific competition and or by contributing to indirect or direct mortality. Although bears in Whistler may continue to use this high value habitat for spring food or as movement corridors, it may become compromised over time depending on the availability of attractants and the level of physical construction attending the course. Therefore, in general, there appears to be very few long-term benefits to bears living near a golf course (Miistakis Institute, 2000).

This may be especially concerning for a single female or a female with cubs becuase I found a positive correlation between habitat value and bear abundance for females. This connotes that female bears may use a golf course as forage sites during months of high forage value. Fortuitously, I also found that distance from urban areas had an effect on female abundance, and therefore may play a role in limiting the number of female bears using the golf courses for foraging purposes.

Interaction effects between bear abundance, distance from urban areas, and habitat value were detected for females, thus, suggesting that females select for high value forage habitat away from urban areas. The testing of these variables has also provided data, which offer more insight into the level in which female bears are food conditioned. The results suggest that female bears use the habitat based on its seasonal value and are less tolerant of human disturbance. This may be one reason for the high number of females identified on Whistler and Blackcomb Mountain, which have overlapping home ranges and limited movement dispersal.

Dissimilarly, the lack of correlation between these variables for male bears is indicative of the high level in which these bears are both food conditioned and human habituated. This may be a direct result of the sparsely distributed high forage value habitats that encompass the large home ranges required by males; thus, resulting in the supplementation of non natural foods such as garbage, which is most commonly found in densely populated urban areas.

CONCLUSION

During the summer and fall of 2003, I used non-invasive black bear DNA hair snagging and identified 50 unique black bears, including 29 females and 21 males. During the first session, which ran from July 3 to August 4, 2003, hair samples were collected weekly from each of the hair snagging sites and black bears were identified 87 times. During the second session, which ran from August 19 to November 11, black bears were identified 56 times.

The Resort Municipality of Whistler has made great progress in bear proofing its community and becoming closer to achieving Bear Smart Status. However, despite bear-proof garbage receptacles for pedestrians, fencing of the entire landfill and changing gate systems, ongoing education programs, and enforcement of existing bylaws especially with respect to housing of commercial dumpsters, bears continue to receive non natural and anthropogenic food sources. Good indicators of this is the abundance of black bears identified at hair snagging sites in commercial and residential areas including, the Whistler land fill, White Gold, Brio and Bayshores residential areas, and the Riverside campground.

My research study supports the notion that male bears continue to maintain a high level of habituation to people and are food conditioned. Furthermore, I found that male bears require a larger area to meet their biological requirements. Consequently, high value forage habitat areas are mainly in isolated patches along the south side of highway

99, limiting male bears in particular, from encountering adequate suitable habitat, especially during the summer and fall seasons.

In contrast, females appeared to use their habitat according to habitat value, which is a good indicator that they are less reliant then male bears on non-natural food sources. My data suggested that female black bears were more likely to use areas on Whistler and Blackcomb Mountain and their ranges overlap with those of other bears. I consider the moderate habitat quality in surrounding areas and more noticeably on the northwestern side of Whistler typical during summer and fall months, thereby contributing to the abundance of bears on Whistler and Blackcomb Mountains during this time. Many of the high forage value areas for black bears were commonly identified on, golf courses, playing fields, power lines, and or nearby the ski runs that act like continuously maintained avalanche tracks. Consequently, many of these high value forage areas are also high human use areas. With the ongoing reduction of available non natural food sources, and the inadequately distributed high black bear forage areas it will be difficult to eliminate the use of residential areas by male bears and prevent continued human-bear conflicts. Whistler continues to develop and expand, critical habitat will continue to be lost, thereby fragmenting and isolating the high quality habitat even more. Conservation, management, and possibly even enhancement of herbaceous species are vital to maintaining or even increasing the habitat quality throughout Whistler.

High value spring foraging areas with high concentrations of herbaceous species should be protected from development and other activities. This may entail the temporary closure of some recreation trails or even permanent closer or relocation of those in very high value forage habitat. Herbaceous species tend to be strongly associated with wet relatively stable ecosystems like riparian areas, wet forest, meadows, and avalanche tracks (Stamp, 2002). Adequate buffer zones should be maintained around these areas to provide bears with sufficient security cover as forage areas that are a significant distance from cover will not be maximally used by bears (Zager et al. 1983).

Berry producing plants are crucial for summer forage by black bears and are limited in many areas throughout Whistler, more critically on the northwestern side of the RMOW. A power line which runs through this area provide bears access to berry producing shrubs but is not adequate to support continuos use by bears. Maintenance and enhancement of berry producing shrubs away from the developed areas is particularly important to reduce the abundance of bears in high human conflict areas. A range of forest management strategies can successfully conserve and enhance berry-producing forage by increasing its abundance and productivity. Enhancement, which may include stand thinning on the north side or fire retention, will increase the light attenuation into the understory throughout the forest rotation. Any form of enhancement of berry producing sites should include a range within biogeoclimatic zones to compensate for intra-annual and inter-annual variability in berry productivity.

However, before any management initiatives begin, it is important to gather base line information. Detailed seasonal habitat mapping to understand the potential, suitability and use of habitat by black bears is necessary to successfully develop methods that will maintain, conserve, and enhance forage species that are pertinent to black bear forage behaviour within Whistler. In conjunction with ground transects the use of seasonal habitat weighting coefficients and Terrestrial Ecosystem Mapping is a reliable method for developing a habitat map which would provided data to aid in the reduction of habitat fragmentation, maintenance of wildlife corridors, and conservation and management of high black bear habitat, which will ultimately reduce human-bear conflicts, therefore supporting the coexistence of humans and bears within the Resort Municipality of Whistler.

I therefore recommend that:

- **areas with high concentrations of herbaceous species be protected from development and other activities.**
- **temporary closure of some recreation trails or even permanent closer or relocation of those in very high value forage habitat.**
- **adequate buffer zones should be maintained around riparian areas, wet forest, meadows, and avalanche tracks.**
- **enhance berry-producing forage by stand thinning on the north side or fire retention to increase the light attenuation into the understory**
- **non-natural feeding opportunities for bears are eliminated.**

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TABLES

Table 1. Proportion of study area within biogeoclimatic units.

Biogeoclimatic unit	Proportion of study area
ATc	12.32%
CWHms1	63.95%
MHmm2	20.14%
MHmmp2	3.60%
Total	100.00%

Table 2. The total number of unique female and male black bears identified at hair snagging sites in the Resort Municipality of Whistler.

Hair Snag Site	Individual Females	Individual Males	Total Individuals
1	2	0	2
2	0	0	0
3	2	2	4
4	0	1	1
5	2	1	3
6	1	0	1
7	1	0	1
8	1	0	1
9	0	0	0
10	0	0	0
11	1	2	3
12	1	3	4
13	1	1	2
15	1	2	3
16	1	1	2
17	0	0	0
18	0	0	0
19	1	1	2

Hair Snag Site	Individual Females	Individual Males	Total Individuals
20	3	2	5
21	4	3	7
22	3	1	4
23	4	2	6
24	3	0	3
25	2	0	2
26	2	2	4
27	3	1	4
28	4	2	6
29	2	2	4
30	1	1	2
31	0	0	0
32	0	0	0
33	1	0	1
34	1	2	3
35	0	1	1
36	2	0	2
37	1	1	2
38	0	0	0
39	1	0	1
40	1	0	1
41	1	1	2
42	1	2	3
43	0	1	1
44	1	0	1
45	1	3	4
46	0	0	0
47	0	0	0
48	1	3	4
49	0	0	0
50	1	1	2
51	1	1	2

Table 3. Black bear abundance at hair snagging sites during the summer and fall sampling sessions, characterized by multiple bear identification and uniquely identified bears.

The summer and fall sampling session	**Summer total**	**Total percent**	**Fall total**	**Total percent**
Total number of bears identified including bears identified more than once in the same week	87	N/A	56	N/A
Total number of bears identified excluding bears identified multiple times in the same week	70	N/A	46	N/A
Total unique individuals	34	76%	24	53%
Total unique identified once	14	41%	9	38%
Total unique identified more than once	20	59%	15	63%

Table 4. Summary statistics of the number of bears identified at hair snagging sites during the summer and fall sampling sessions including those hair samples from bears that were identified at multiple hair snagging sites during the same sample week.

	Total	Female	Male
Summer total	87	63	24
Fall total	56	34	22
Summer/Fall Total	143	97	46

Table 5. A summary of the total number of times unique bears were identified at hair snagging sites during both sampling sessions.

The number of times bears were identified during both sampling seasons	The number of unique bears identified	The total percent of unique bears
13	1	2%
12	0	0%
11	0	0%
10	1	2%
9	0	0%
8	3	7%
7	2	4%
6	2	4%
5	2	4%
4	1	2%
3	7	16%
2	10	22%
1	16	36%

Table 6. A summary of the number of times that unique bears were identified at multiple hair snagging sites during the same week.

Summer	Female bears	Male bears	Fall	Female bears	Male bears
10	7/10	3/10	6	3/6	3/6

Table 7. A summary of the number of times that a unique bear was identified at the same hair snag site during both sampling sessions.

The number of times female bears were identified at the same hair snagging sites	Number of bears	Total percent	The # of times male bears were identified at the same hair snagging sites	Number of bears	Total percent
9	1	4%	9	0	0%
8	1	4%	8	0	0%
7	1	4%	7	0	0%
6	0	0%	6	0	0%
5	2	7%	5	0	0%
4	0	0%	4	1	5%
3	6	22%	3	1	5%
2	4	15%	2	3	14%
1	12	44%	1	17	77%

Table 8. A summary of the average distances between the nearest and furthest consecutive hair snag site where unique black bears were identified; (a) is including only those bears identified at multiple hair snagging sites and; (b) is including those bears identified only at the same hair snag site, thus, have an average distance to nearest hair snagging sites of zero; (c) includes mean distance difference and summary between male and female black bears identified at multiple hair snagging sites and; (d) includes the mean distance difference and summary between male and female black bears, including those identified at the same hair snag site only.

(a) Excluding zero	Nearest hair snagging sites		Further distance to hair snagging sites	
	Female	Male	Female	Male
max	5082	5907	5082	6601
min	809	2295	809	2295
median	2437	5235	3390	6162
mean	2727	4829	3014	5434

(b) Including Zero	Nearest hair snagging sites		Further distance to hair snagging sites	
	Female	Male	Female	Male
max	5082	5907	5082	6601
min	0	0	0	0
median	1878	5106	2156	6034
mean	1741	4024	2072	4528

Difference between female and male excluding zero	Nearest hair snagging sites	Furthest distance to hair snagging sites
max	825	1519
min	1486	1486
median	2798	2772
mean	2102	2420

Including zero	Nearest hair snagging sites	Furthest distance to hair snagging sites
max	825	1519
min	0	0
median	3228	3878
mean	2283	2456

Table 9. Compilation of spring foods consumed by black bears

1. spring food species in the RMOW	
(a) early to middle spring	
Skunk cabbage	*Lysichiton americanum*
Lady fern	*Athyrium filix-femina*
Clover spp.	
Common dandelion	*Taraxacum officinale*
Kinnikinnick	*Arctostaphylos uva-ursi*
Devil's club	Oplopanax horridus
Common horsetail	*Equisetum arvense*
(b) late spring or lower elevations	
Red elderberry	*Sambucus racemosa*
Salmonberry	*Rubus spectabilis*
Thimbleberry	*Rubus parviflorus*

Table 10. Compilation of summer foods consumed by black bears in the Resort Municipality of Whistler.

Summer foods	
Red huckleberry	*Vaccinium parvifolium*
Black huckleberry	*Vaccinium membranaceum*
Bog blueberry	*Vaccinium uliginosum*
Oval-leafed blueberry	*Vaccinium ovalifolium*
Alaskan blueberry	*Vacciniumalaskaense*
Soopolallie	*Shepherdia canadensis*
Crowberry	*Empetrum nigrum*
Salmonberry	*Rubus spectabilis*
Kinnikinnick	*Arctostaphylos uva-ursi*
Crowberry	*Empetrum nigrum*
Red raspberry	*Rubus idaeus*
Western mountain ash	*Sorbus scopulina*
Sitka mountain ash	*Sorbus sitchensis*
Salal	*Gaultheria shallon*
Dwarf or Cascade blueberry	*Vaccinium caespitosum*
Red-osier dogwood	*Cornus stolonifera*
Black currant	*Ribes lacustre*
Sticky currant	*Ribes viscosissimum*
Red elderberry	*Sambucus racemosa*
Bitter cherry	*Prunus emarginata*
Thimbleberry	*Rubus parviflorus*
Devil's club	*Oplopanax horridus*

Summer foods	
Dull Oregon grape	*Mahonia nervosa*
Wild rose	*Rosa spp*
Black twinberry	*Lonicera involucrata*
Rosy twistedstalk	*Streptopus roseus*
Common horsetail	*Equisetum arvense*
Indian hellebore	*Veratrum viride*
Hooker's fairybell	*Disporum hookeri*
Ants	*Camponotus pennsylvanicus*

Table 11. Compilation of early to late fall foods consumed by black bears in the Resort Municipality of Whistler.

3. Fall foods	
(a) early fall foods	
Wild rose	*Rosa*
Red elderberry	*Sambucus racemosa*
Alaskan blueberry	*Vaccinium alaskaense*
Grasses and sedges	*Carex, Agrostis*
Common horsetail	*Equisetum arvense*
Ants	*Camponotus pennsylvanicus*
(b) later fall foods	
Kinnikinnick	*Arctostaphylos uva-ursi*
Saskatoon berry	*Amalanchier alnifolia*
Twistedstalk	*Streptopus amplexifolius*
Grasses and sedges	*Carex, Agrostis*

Table 12. A summary of the percent cover of site series classification within the 250 meter buffered hair snagging sites, which fall in both the MHmm2 and the CWHms1 biogeoclimatic zone.

MHmm2	Site Series	Percent Cover	Total Area (ha)
1	1	58%	789714
2	SK	32%	42630
3	2	3%	2
4	24	3%	10860
5	3	1%	37681
6	9	1%	317
7	70	1%	6074
8	TA	1%	17514
9	54	0.40%	1084
10	OW	0.10%	441892
11	51	0.02%	7565

CWHms1	Site series	Percent cover	Total area (ha)
1	1	35.0%	2549411
2	3	19.0%	218378
3	4	14.0%	1383128
4	UR	12.0%	103951
5	GP	4.0%	89713
6	PL	4.0%	31274
7	BU	3.5%	11328
8	2	3.0%	34307
9	LA	3.0%	85807
10	SK	3.0%	3314
11	6	1.0%	21166
12	22	1.0%	9550
13	SF	1.0%	25299
14	40	0.9%	12462
15	RI	0.6%	61758
16	TA	0.6%	2430
17	11	0.5%	3536
18	GC	0.5%	13601
19	7	0.4%	362969
20	33	0.4%	254242
21	31	0.3%	241424
22	PD	0.3%	3691
23	8	0.2%	25177
24	39	0.2%	292896
25	GB	0.2%	46960
26	RZ	0.2%	144036
27	32	0.1%	75871

28	OW	0.1%	235266
29	23	0.1%	43432
30	ES	0.1%	841729

Table 13. Preferred and occasionally used black bear foods in the RMOW. Food groups are berries-shrubs and herbs, foliage shrubs, foliage-forbs and ferns, horsetails, graminoids, mammals and insects.

Black bear forage species in the RMOW	
1. Berry producing forage group	
(a) Prefered food plant species berries	
Red huckleberry	*Vaccinium parvifolium*
Black huckleberry	*Vaccinium membranaceum*
Bog blueberry	*Vaccinium uliginosum*
Oval-leafed blueberry	*Vaccinium ovalifolium*
Alaskan blueberry	*Vacciniumalaskaense*
Soopolallie	*Shepherdia canadensis*
Crowberry	*Empetrum nigrum*
Salmonberry	*Rubus spectabilis*
Kinnikinnick	*Arctostaphylos uva-ursi*
Crowberry	*Empetrum nigrum*
Highbush-cranberry	*Vibernum edule*
Red raspberry	*Rubus idaeus*
Western mountain-ash	*Sorbus scopulina*
Sitka mountain-ash	*Sorbus sitchensis*
Salal	*Gaultheria shallon*
Dwarf or Cascade blueberry	*Vaccinium caespitosum*
Red-osier dogwood	*Cornus stolonifera*
Black currant	*Ribes lacustre*
Sticky currant	*Ribes viscosissimum*
Red elderberry	*Sambucus racemosa*
(b) ocassionaly used berries	
Bitter cherry	*Prunus emarginata*
Thimbleberry	*Rubus parviflorus*
Devil's club	*Oplopanax horridus*
Dull Oregon grape	*Mahonia nervosa*
Tall Oregon grape	*Mahonia aquifolium*
Wild rose	*Rosa*
Black twinberry	*Lonicera involucrata*
Highbush-cranberry	*Vibernum edule*

Black bear forage species in the RMOW	
2. Herbaceous forage group[	
(a) Prefered plant specied	
Cow-parsnip	*Heracleum lanatum*
Common horsetail	*Equisetum arvense*
Other horsetail spp.	
Skunk cabbage	*Lysichiton americanum*
Common dandelion	*Taraxacum officinale*
Clover spp.	
Lady fern	*Athyrium filix-femina*
False Solomon's-seal	*Smilacina racemosa*
Star-flowered false Solomon's-seal	*Smilacina stellata*
(b) ocasionaly used forage group	
Indian hellebore	*Veratrum viride*
Hooker's fairybell	*Disporum hookeri*
Rosy twisted stalk	*Streptopus roseus*
Western meadowrue	*Thalictrum occidentale*
Stinging nettle	*Urtica dioica*
Baneberry	*Actaea rubra*
Edible thistle	*Cirsium edule*
Thistle spp.	
Mountain sorrel	*Oxyria digyna*
Kneeling angelica	*Angelica genuflexa*
(c) Grasses Poaceae	
Hairgrass spp.	
(d) SEDGES	
(e) MAMMALS	
Black-tailed deer (*Odocoileus hemionus*)	*Odocoileus hemionus*
(f) Insects	
Ants	*Camponotus pennsylvanicus*

Table 14. Correlation between black bear forage habitat values, derived by; seasonal weighting coefficients multiplied by percent area of site series classifications; and, abundance of bear forage species derived by field transects.

Variable	by Variable	Spearman Rho	Prob>|Rho|
spring ss rank	spring ground rank	0.574849	0.001
summer ss rank	summer ground rank	0.470968	0.001253
fall ss rank	fall ground rank	0.426173	0.003921

Table 15. Seasonal frequency distribution of forage habitat values across all of the hair snagging sites in the RMOW.

	Spring	Summer	Fall
Habitat value			
1 = very low	5	4	8
2 = low	12	7	11
3 = moderate	9	19	24
4 = high	9	15	5
5 = very high	13	3	0
Quantiles			
100.0% maximum	5	5	4
99.5%	5	5	4
97.5%	5	5	4
90.0%	5	4	4
75.0% quartile	5	4	3
50.0% median	3	3	3
25.0% quartile	2	3	2
10.0%	1	2	1
2.5%	1	1	1
0.5%	1	1	1
0.0% minimum	1	1	1
Moments			
Mean	3.2	3.1	2.6
Std Dev	1.4	1.	0.8
Std Err Mean	0.2	0.1	0.1
upper 95% Mean	3.7	3.4	2.8
lower 95% Mean	2.8	2.8	2.3
N	48.	48	48

C

Table 16. (a) Correlation between seasonal black bear forage habitat values and abundance of bears identified at hair snagging sites, using Spearman's Rank Correlation. (b) Correlation between female and black bear forage seasonal habitat values and abundance of bears identified at hair snagging sites, using Spearman's Rank Correlation.

(a)

	Habitat Rank & Abundance at hair snagging sites	Habitat Rank & Abundance at hair snagging sites
Summer	Rho= 0.328	P= 0.002
Fall	Rho=0.459	P= 0.001

(b)

Habitat Rank & Abundance at hair snagging sites by gender	Female Probability	Female Spearman Rank	Male Spearman Rank	Male Probability
Summer	P= 0.001	Rho= 0.543	Rho= 0.128	P= 0.385
Fall	P= 0.002	Rho= 0.43	Rho= 0.065	P= 0.385

Table 17. (a) Correlation between the distance of hair snagging sites and abundance of bears identified at hair snagging sites. (b) Correlation between the distance of hair snagging sites and the forage habitat values at hair snagging sites.

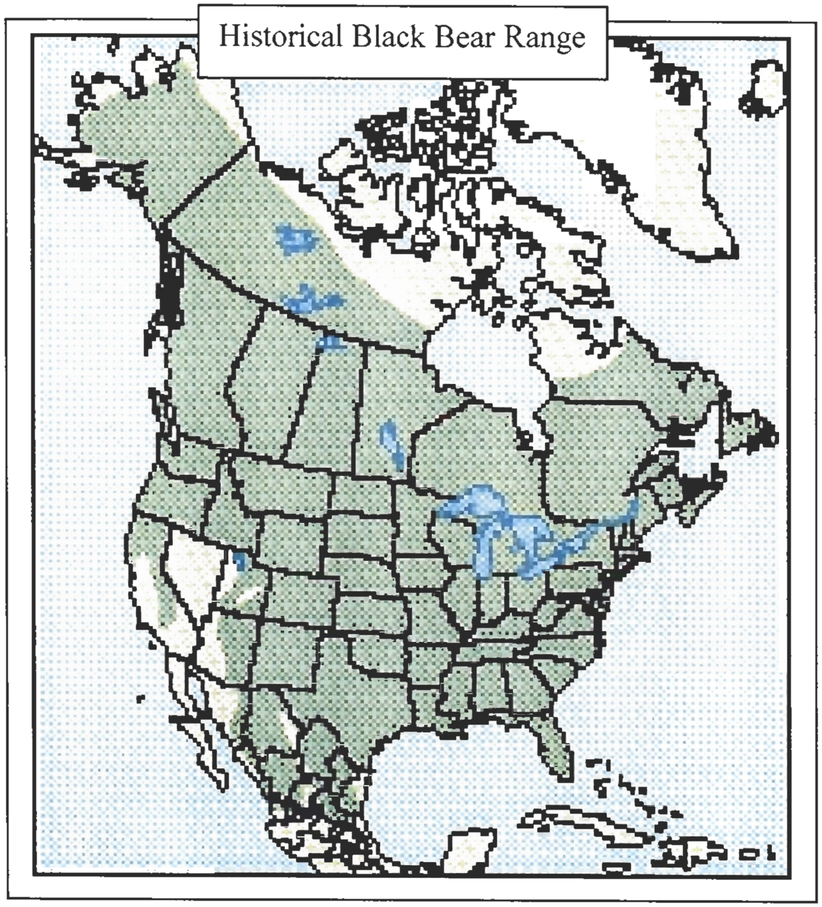
(a)	Spearman Rank	Probability
	Distance from Urban to hair snagging sites and bear abundance	Distance from Urban to hair snagging sites and bear abundance
Summer	Rho= 0.46	P= 0.001
Fall	Rho= 0.40	P= 0.006
(b)		
	Distance from Urban to hair snagging sites and forage habitat value	Distance from Urban to hair snagging sites and forage habitat value
Summer	Rho =0.5	P=0.0001
Fall	Rho =0.5	P=0.0006

Table 18. (a) Correlation between seasonal black bear forage habitat values, bear abundance at hair snagging sites, and distance of snag sites from urban areas, using an ANOVA Fit Least Squares model. (b) Correlation between seasonal female and male black bear abundance at hair snagging sites, forage habitat value, and distance of snag sites from urban areas, using an ANOVA Fit Least Squares model.

Abundance/Distance/Rank	**Summer**	**Fall**
(a)		
Total		
R^2	R^2= 0.22	R^2= 0.27
Prob<	P= 0.06	P= 0.008
Effects test Rank P=	P= 0.16	P= 0.82
Effects test Distance P=	P= 0.261	P= 0.01
(b)		
Female		
Female R^2	R^2= 0.35	R^2= 0.41
Female Prob	P= 0.002	P= 0.0001
Female Effects test Rank P=	P= 0.08	P= 0.47
Female Effects test Distance P=	P= 0.04	P= 0.001
Male		
Male R^2	R^2= 0.09	R^2= 0.05
Male Prob	P= 0.55	P= 0.66
Male Effects test Rank	P= 0.42	P= 0.56
Male Effects test Distance	P= 0.77	P= 0.66

FIGURES

Figure 1. **Historical and present day American black bear range.**



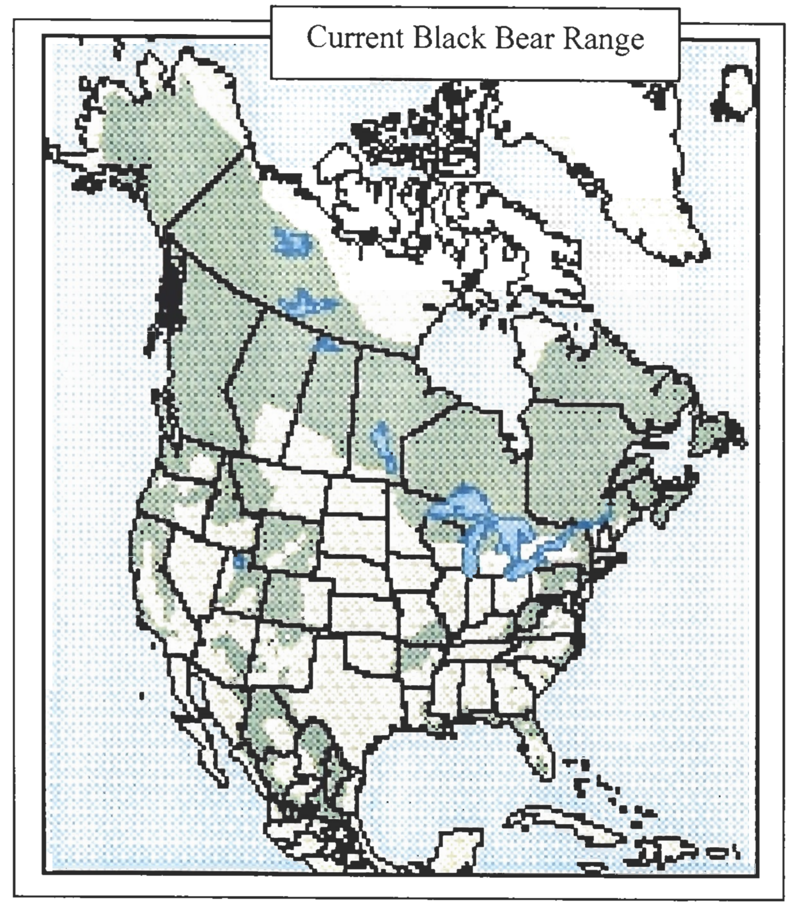


Figure 2. Number of black bears killed by conservation officers in British Columbia from 1992 to 1999.

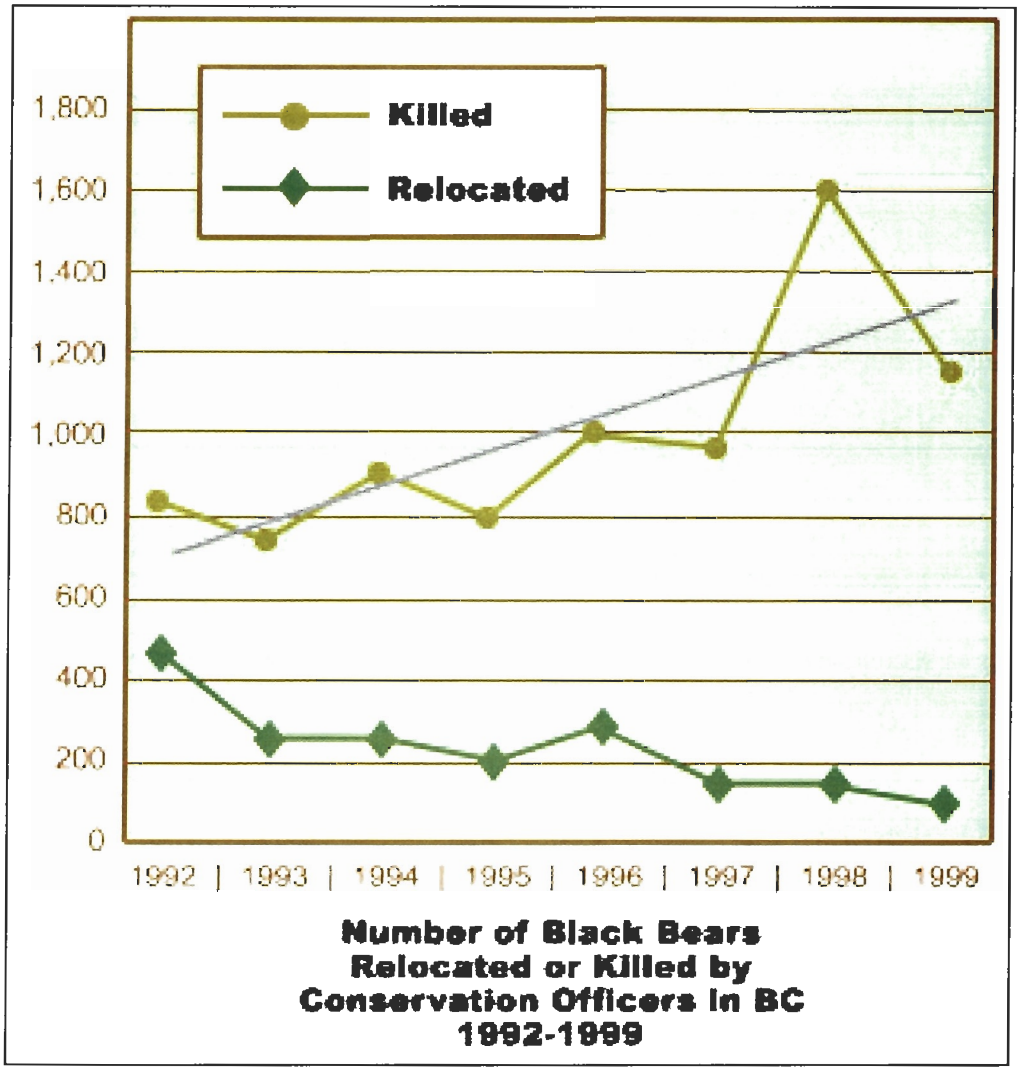


Figure 3. Biogeoclimatic unit distribution within the RMOW . (B.A. Blackwell and Associates Ltd. 2004)

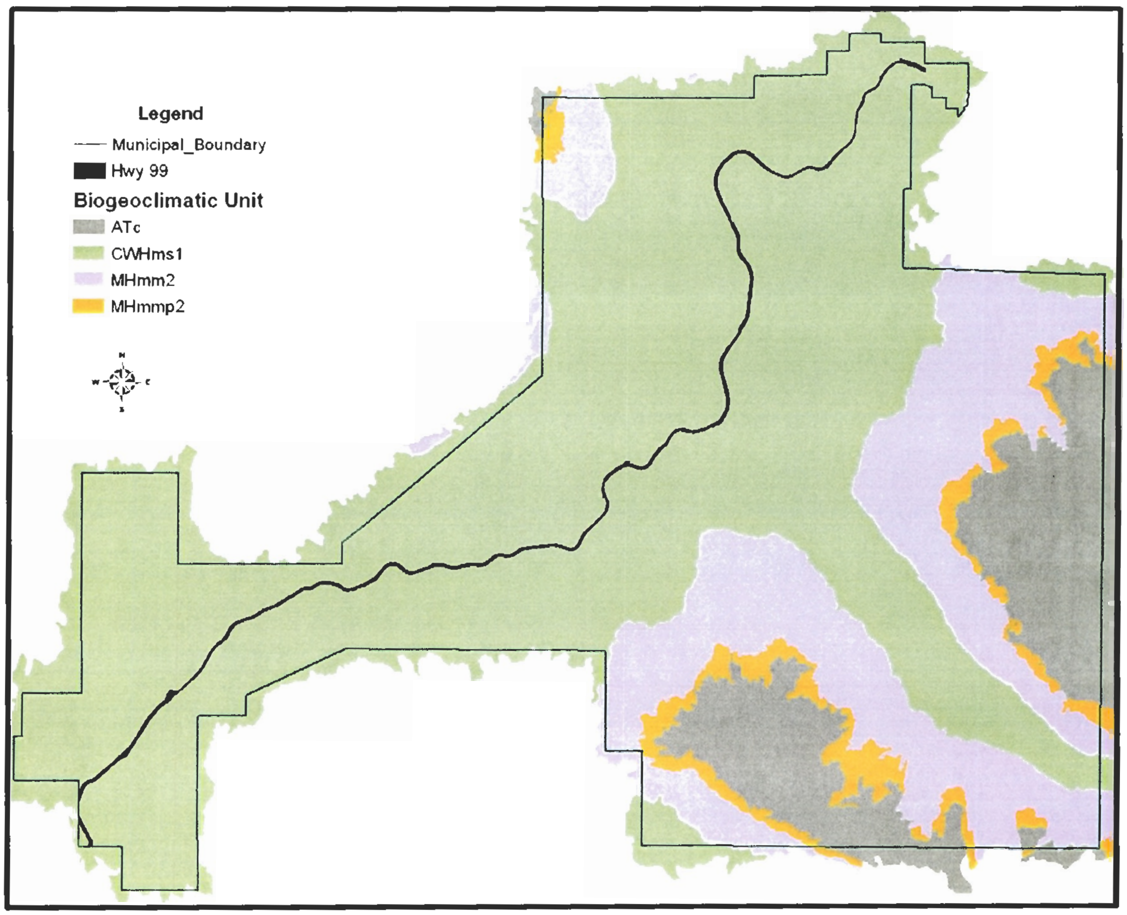


Figure 4. Barbed wire DNA hair snag site construction, where barbed wires are used to obtain bear hair for population estimates

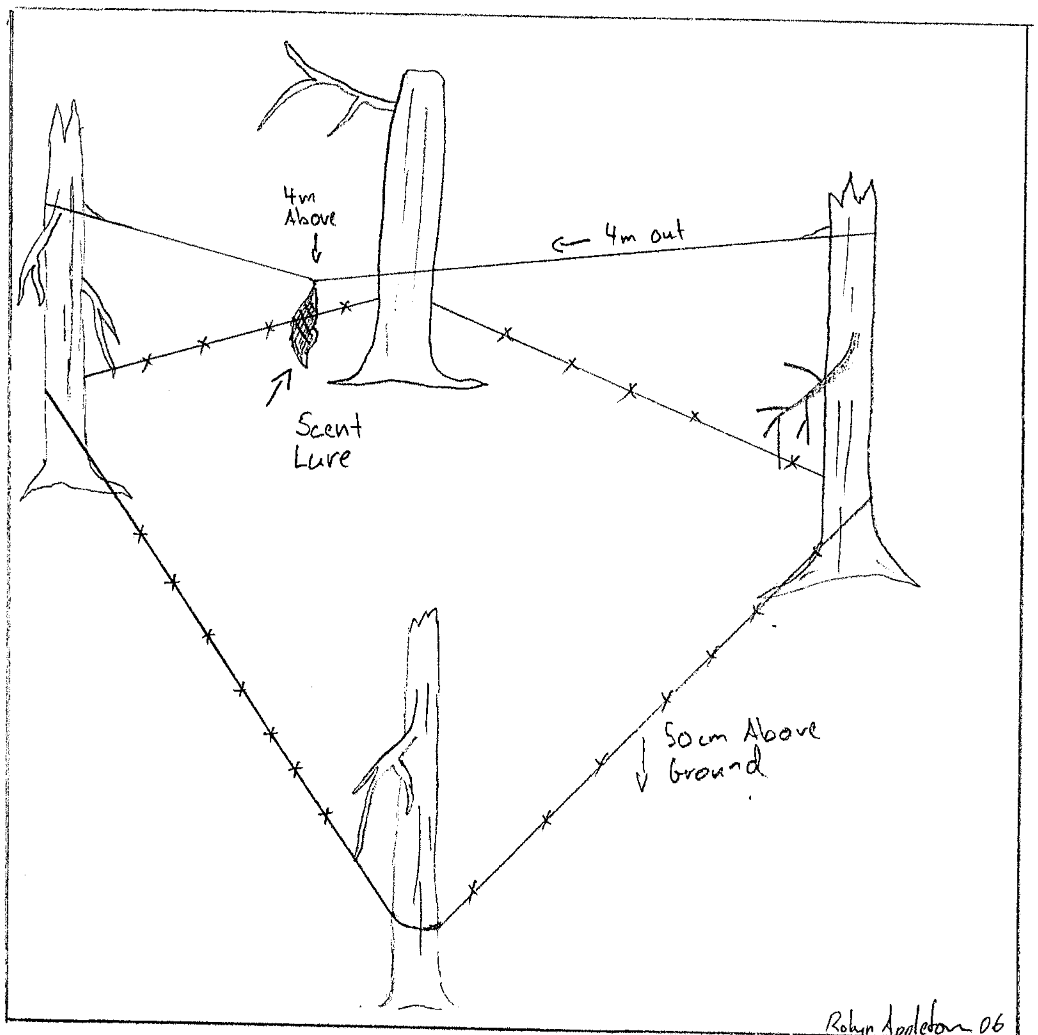


Figure 5. A map displaying the spatial distribution of DNA hair snagging sites throughout the RMOW.

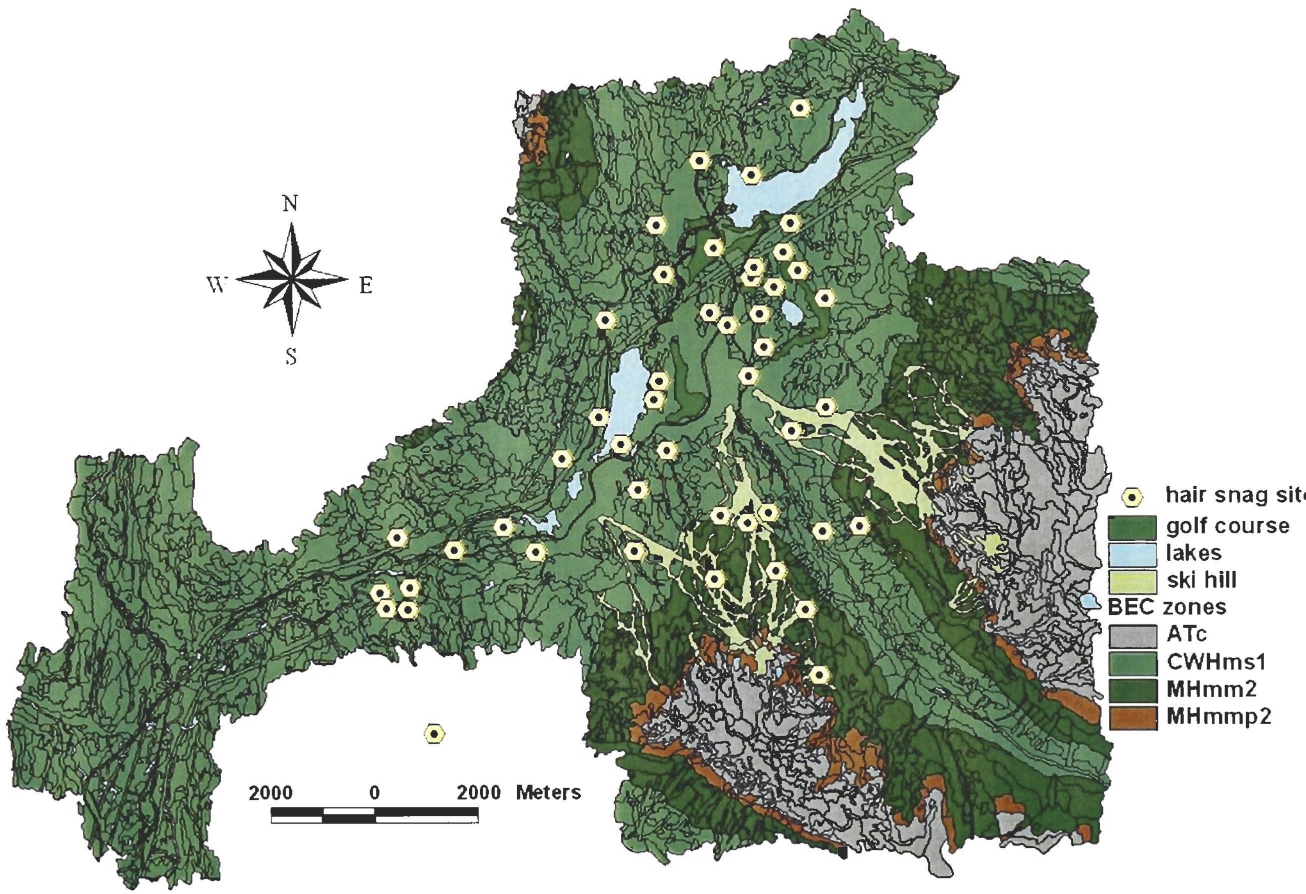


Figure 6. A map including the number of unique black bears identified at each of the hair snagging sites during both the summer and fall DNA hair sampling sessions.

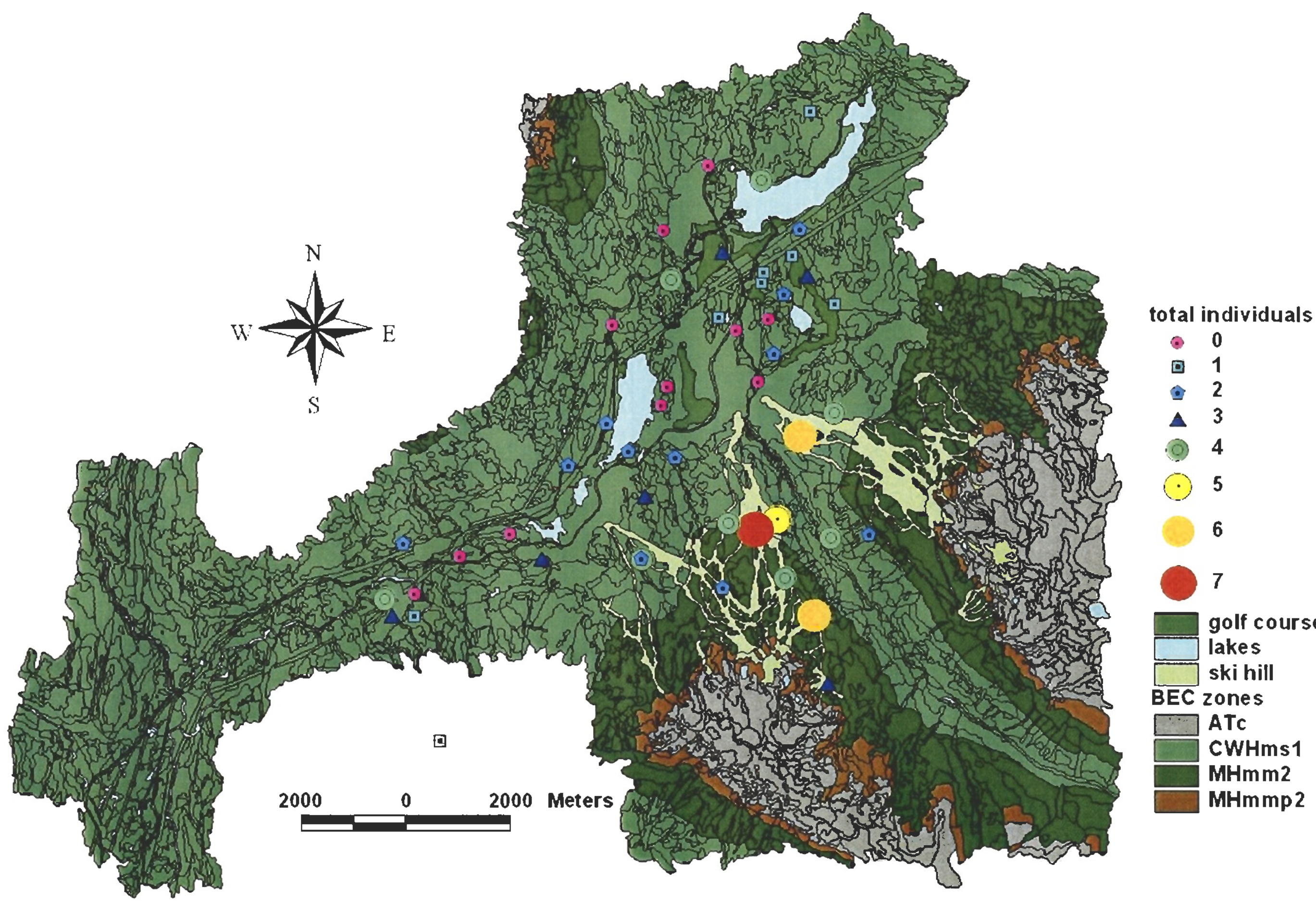


Figure 7. A map including the number of unique female black bears identified at each of the hair snagging sites during both the summer and fall DNA hair sampling sessions.

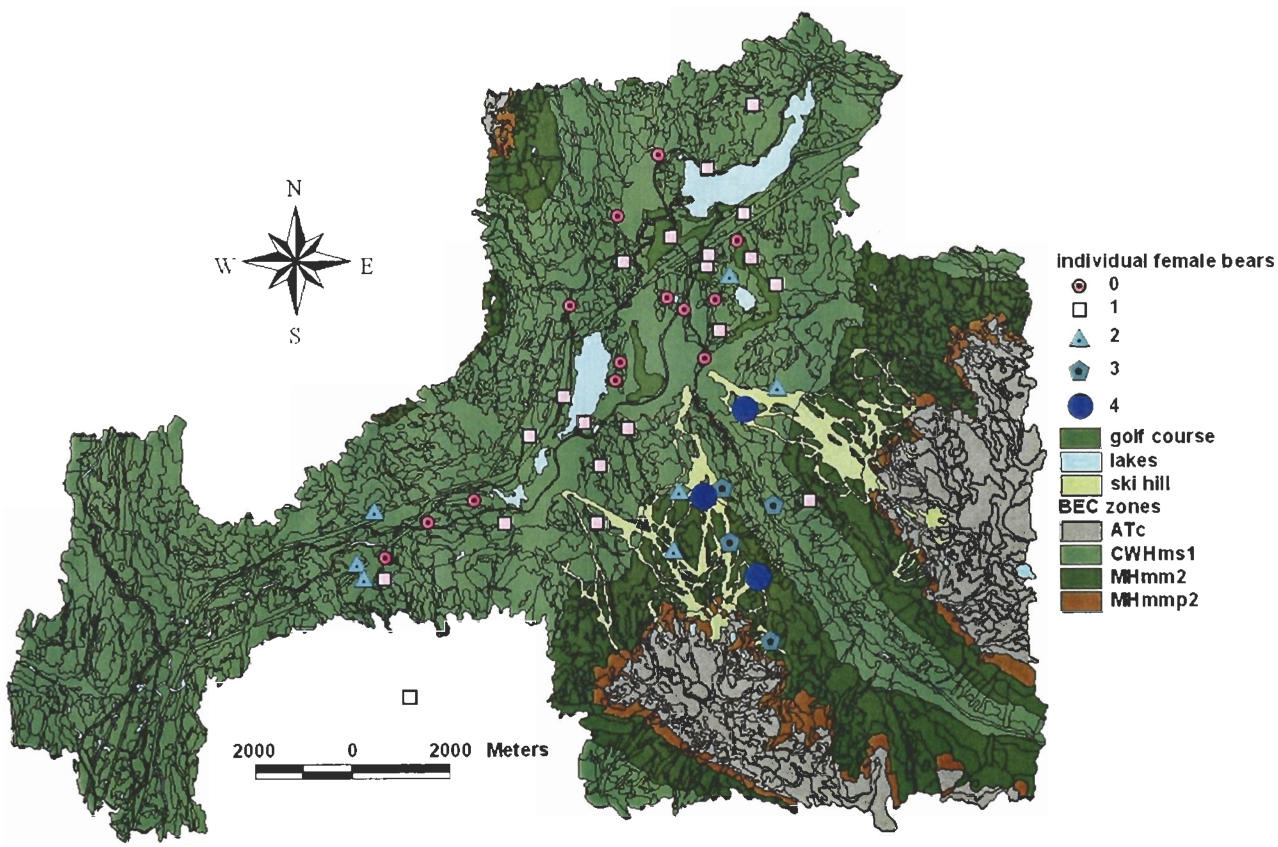


Figure 8. A map including the number of unique male black bears that were identified at each of the hair snagging sites during both the summer and fall DNA hair sampling sessions.

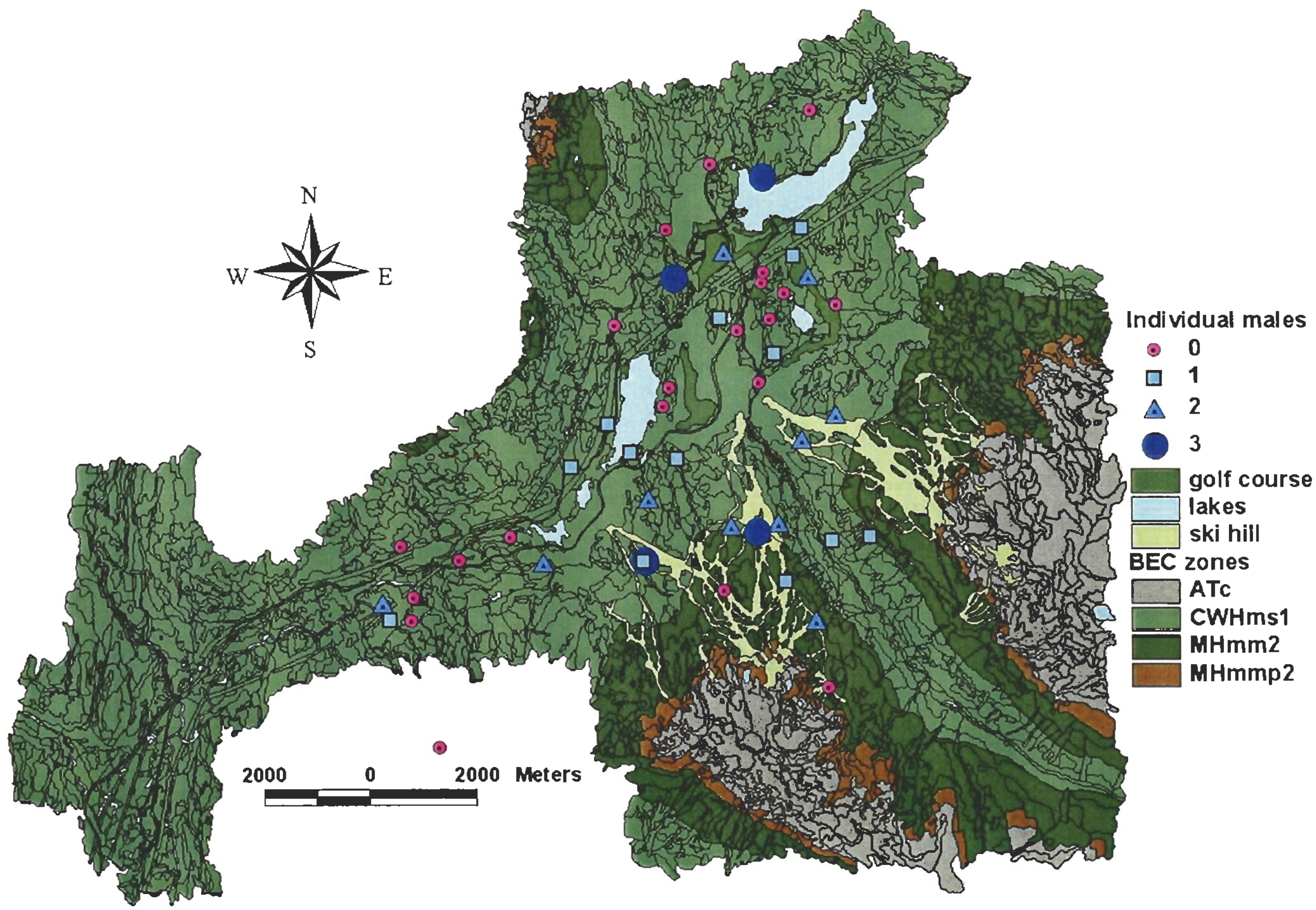


Figure 9. The total number of unique bears identified at DNA hair snagging sites followed by the total abundance of bears identified at DNA hair snagging sites.

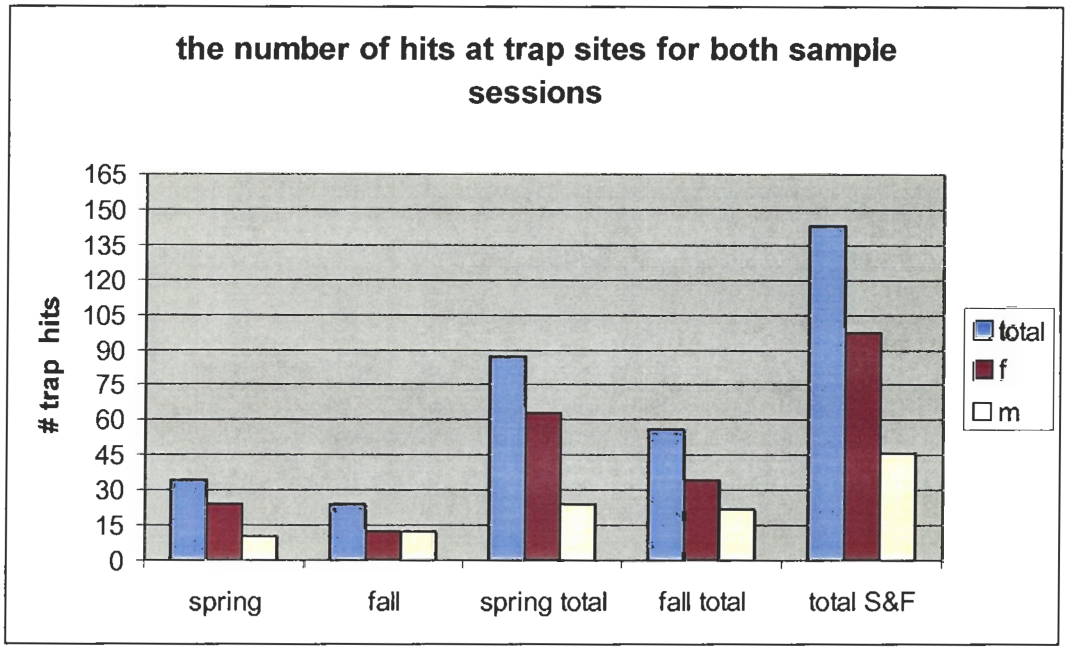
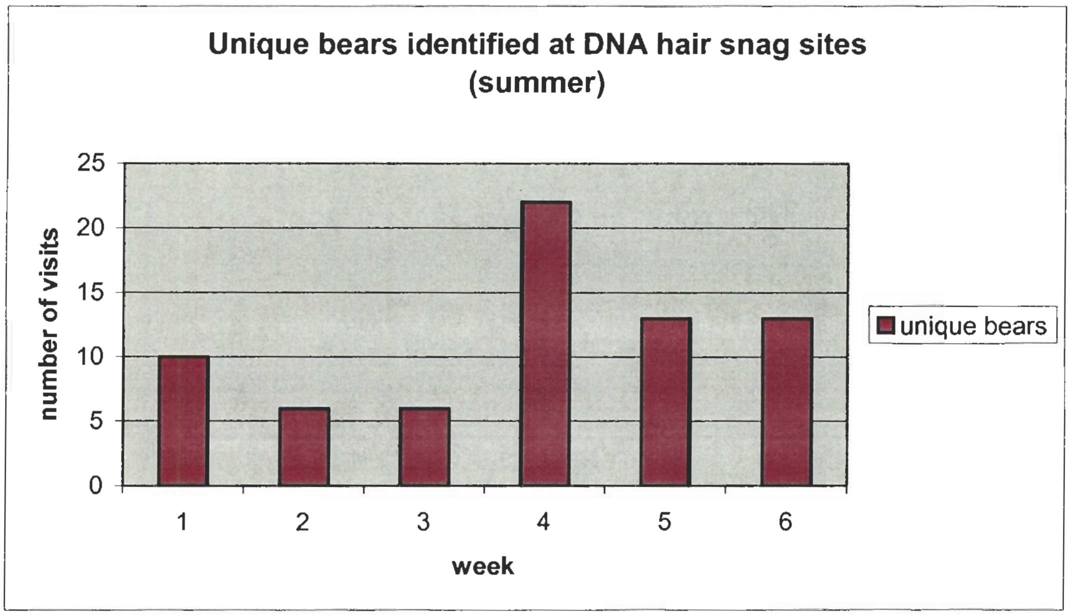


Figure 10. (a) Total number of unique bears identified each week during the summer DNA hair sampling session; (b) the abundance of bears at hair snagging sites each week during the summer DNA hair sampling session.

(a)



(b)

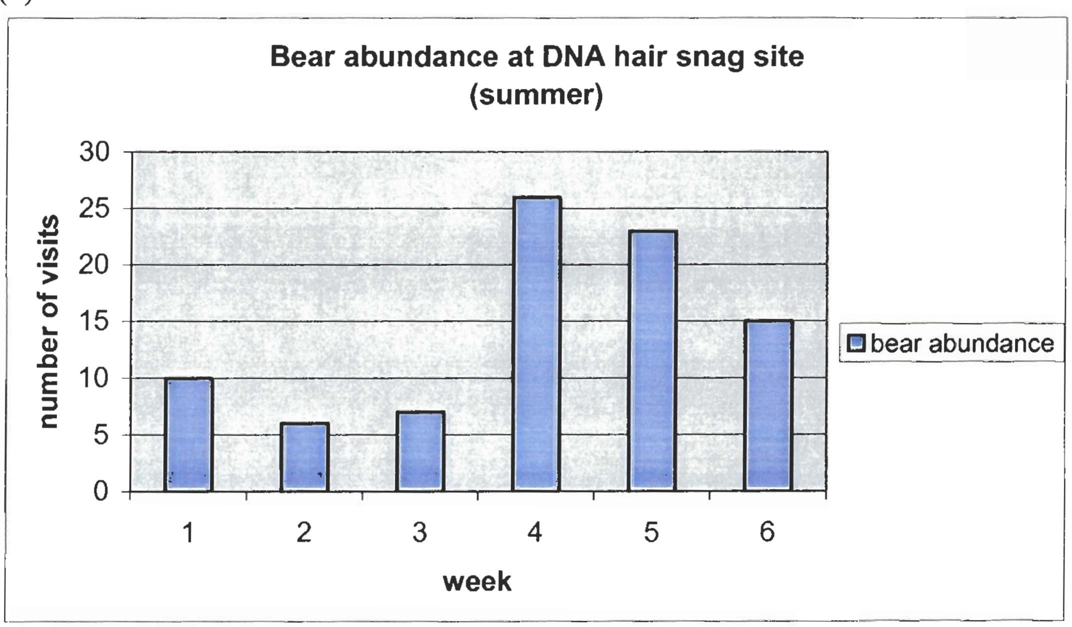
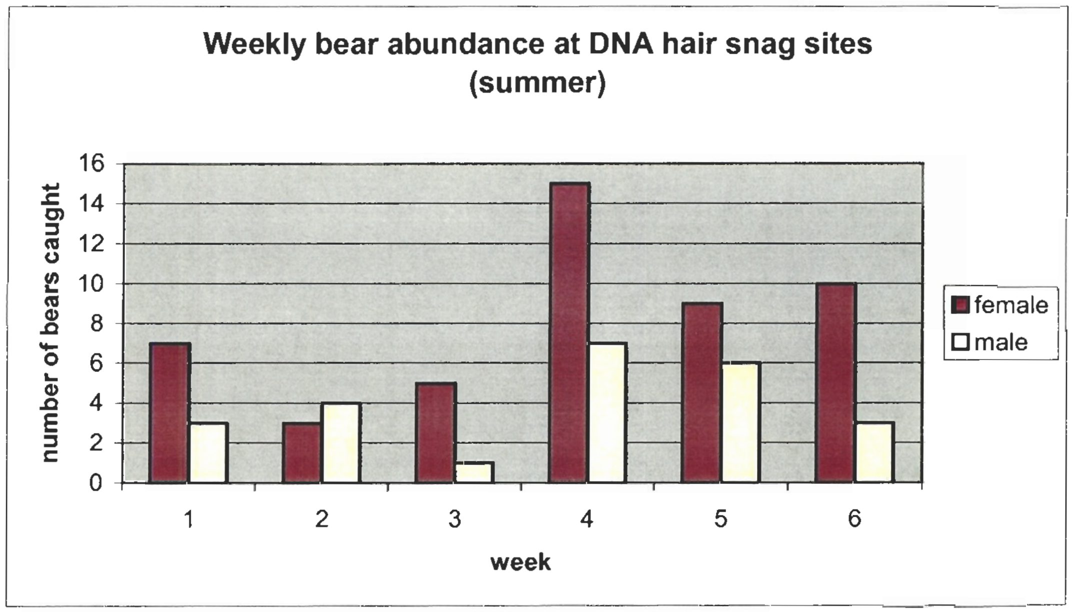


Figure 11. Abundance of male and female bears at hair snagging sites during the summer DNA hair sampling session



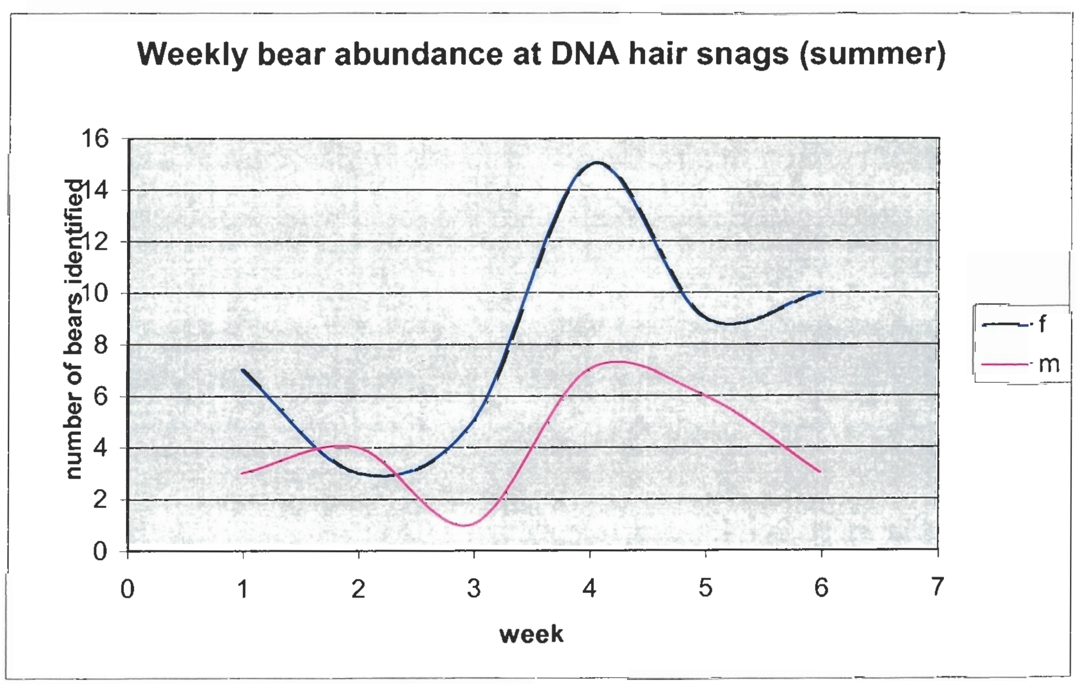
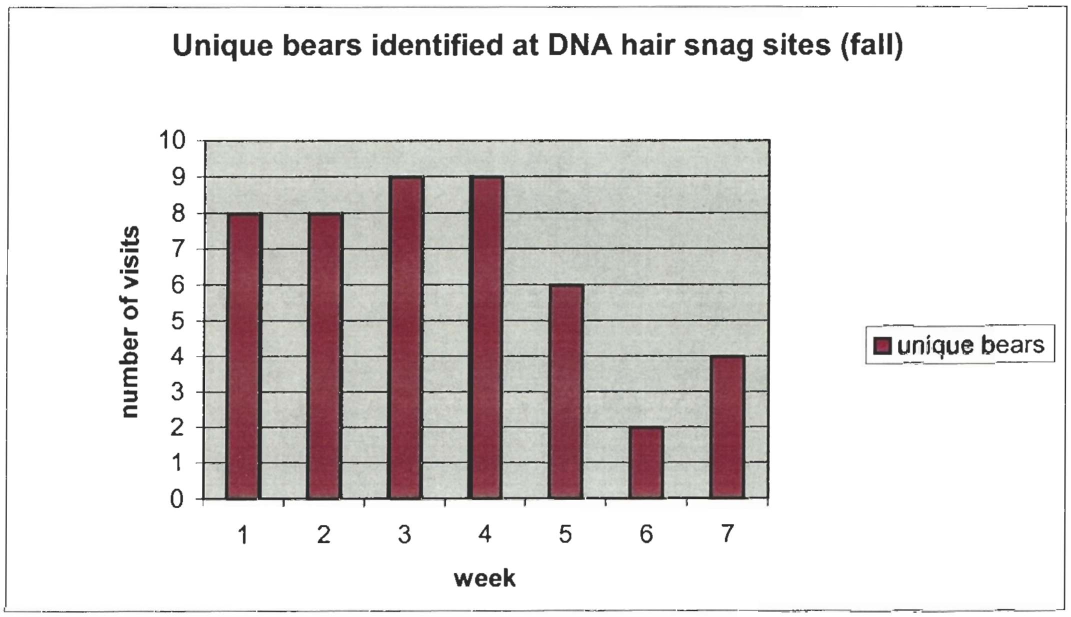


Figure 12 Total number of unique bears identified each week during the fall DNA hair sampling session; (b) the abundance of bears at hair snagging sites each week during the fall.

(a)



(b)

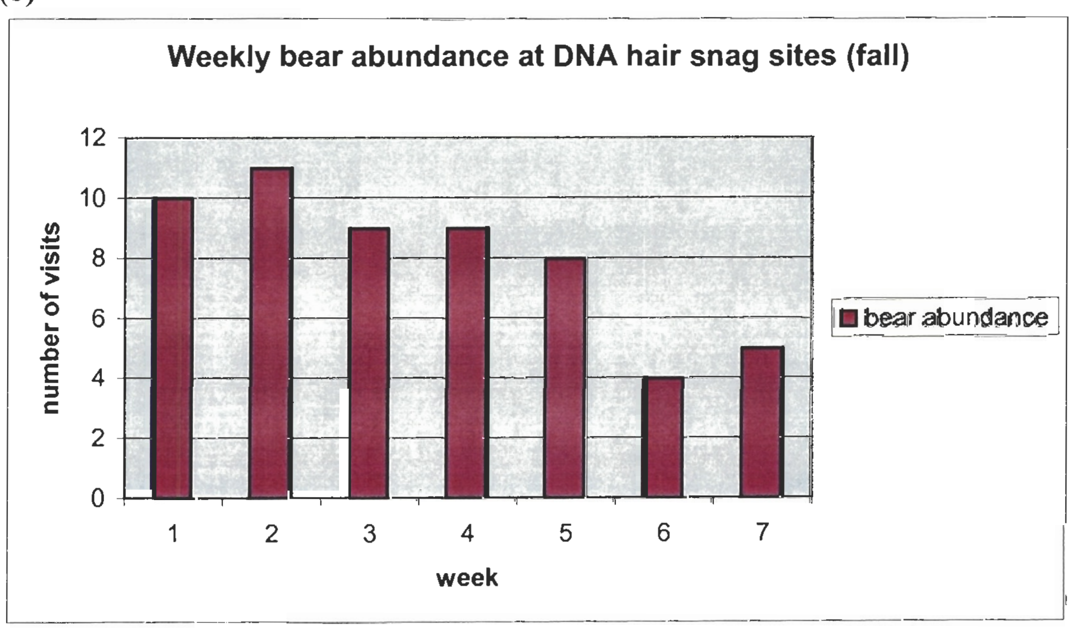
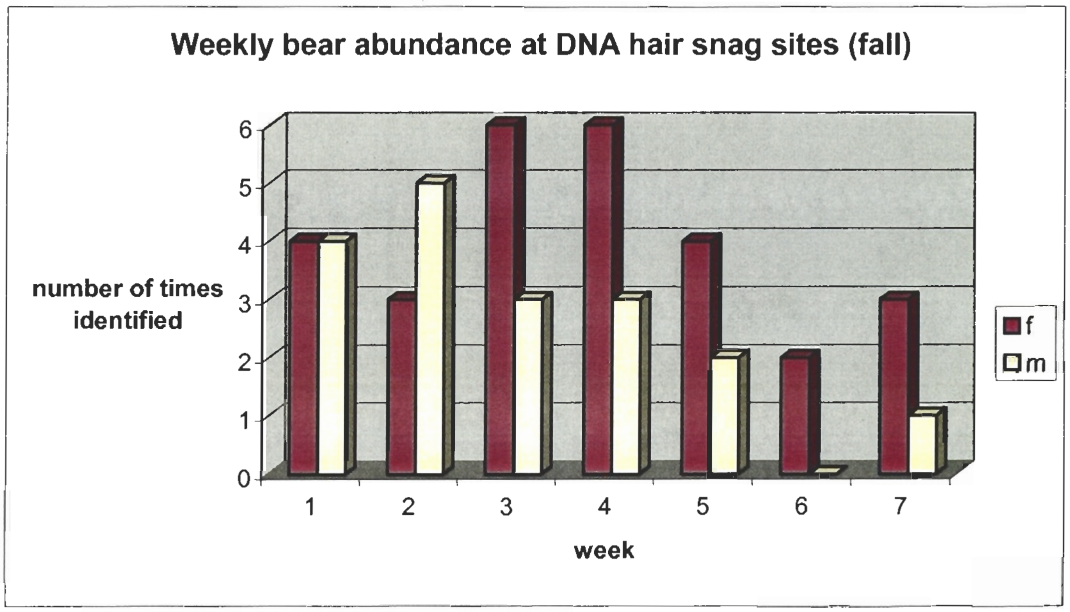


Figure 13. The abundance of male and female bears at hair snagging sites during the fall DNA hair sampling session

(a)



(b)

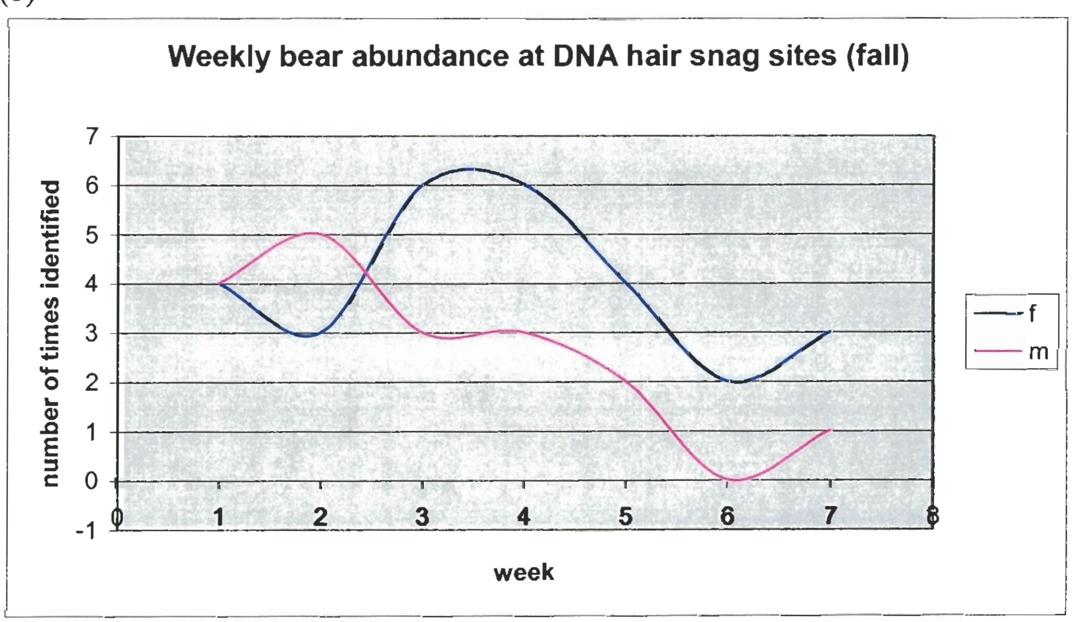
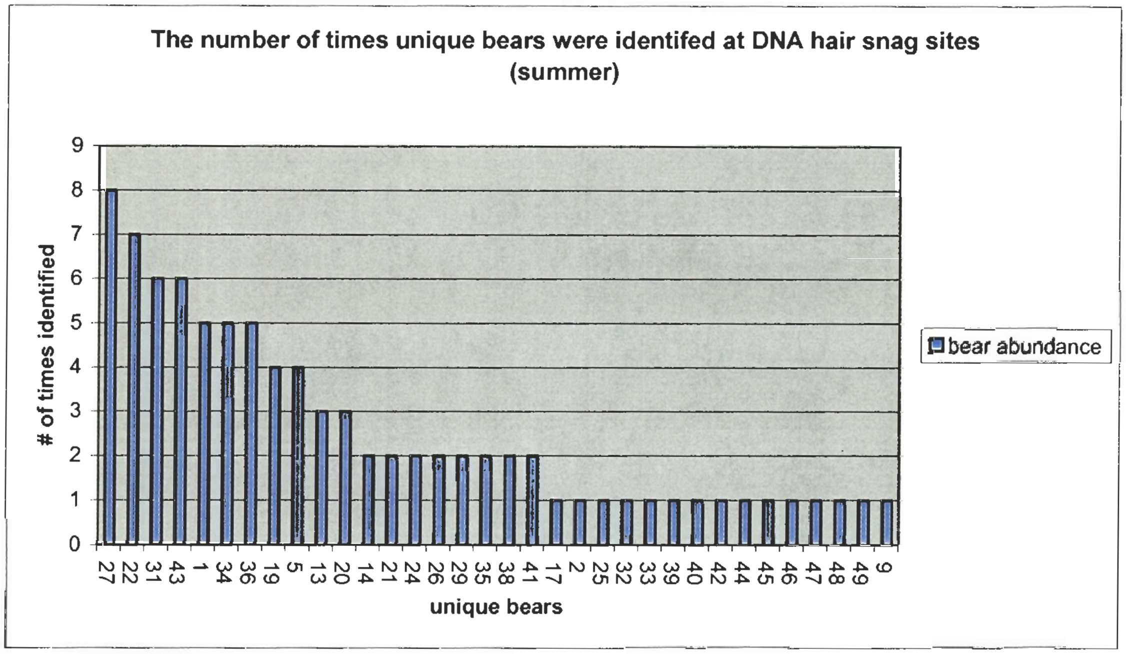


Figure 14. (a) The number of times that each unique bear was identified at the DNA hair snagging sites during the six-week summer bait and collect sampling session; (b) the number of weeks that bears were identified during the summer sampling session

(a)



(b)

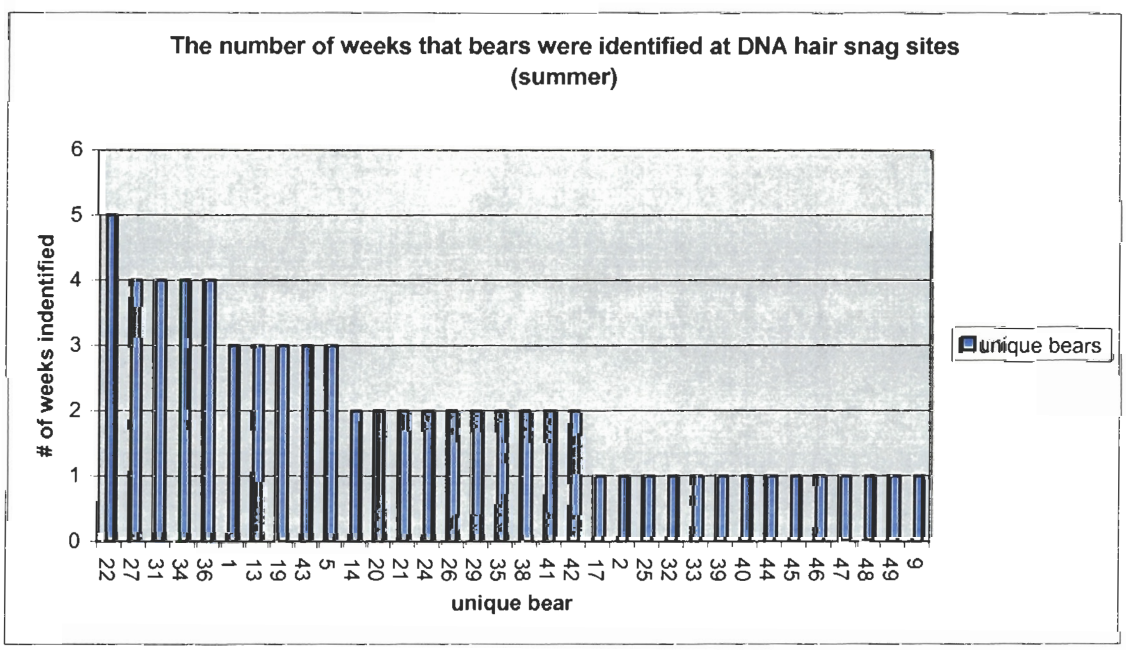
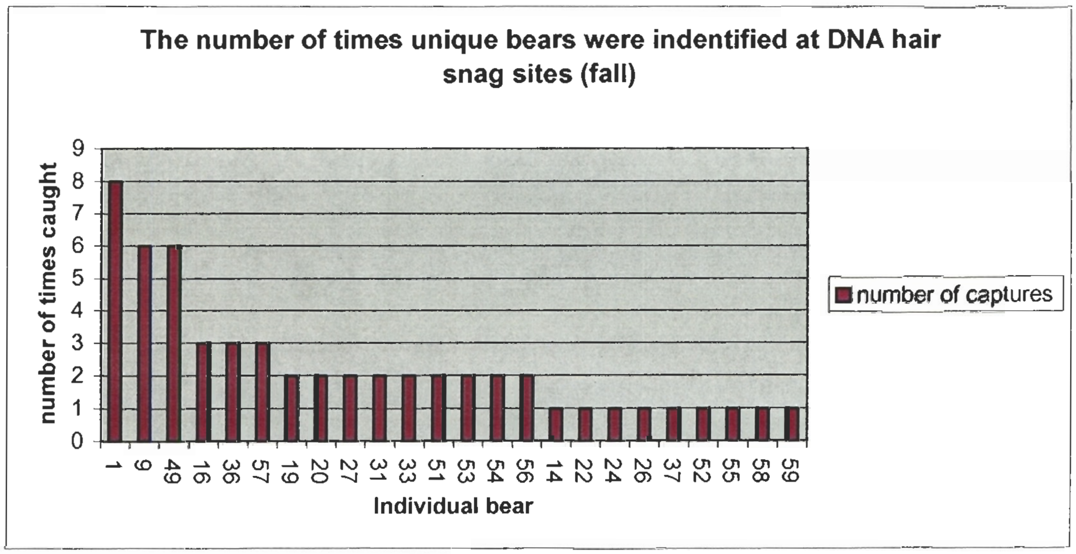


Figure 15. (a) The number of times that each unique bear was identified at the DNA hair snagging sites during the six-week fall bait and collect sampling session; (b) the number of weeks that bears were identified during the fall sampling session

(a)



(b)

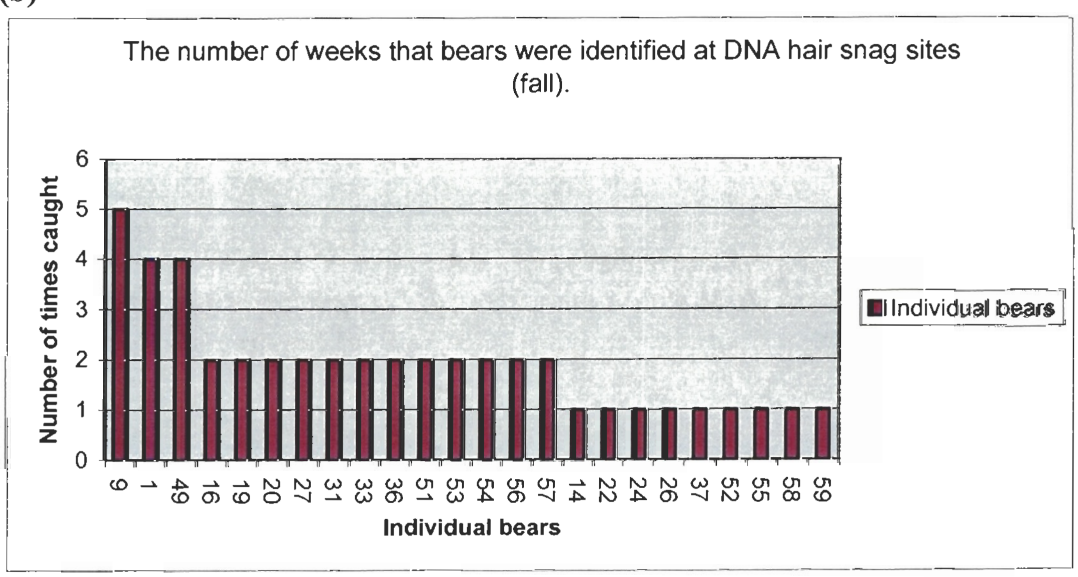


Figure 16. A GIS map which displays each DNA hair snag site that a unique female black bear was identified at three or more times. Each unique bear and the locations in which they were identified at are represented by colour.

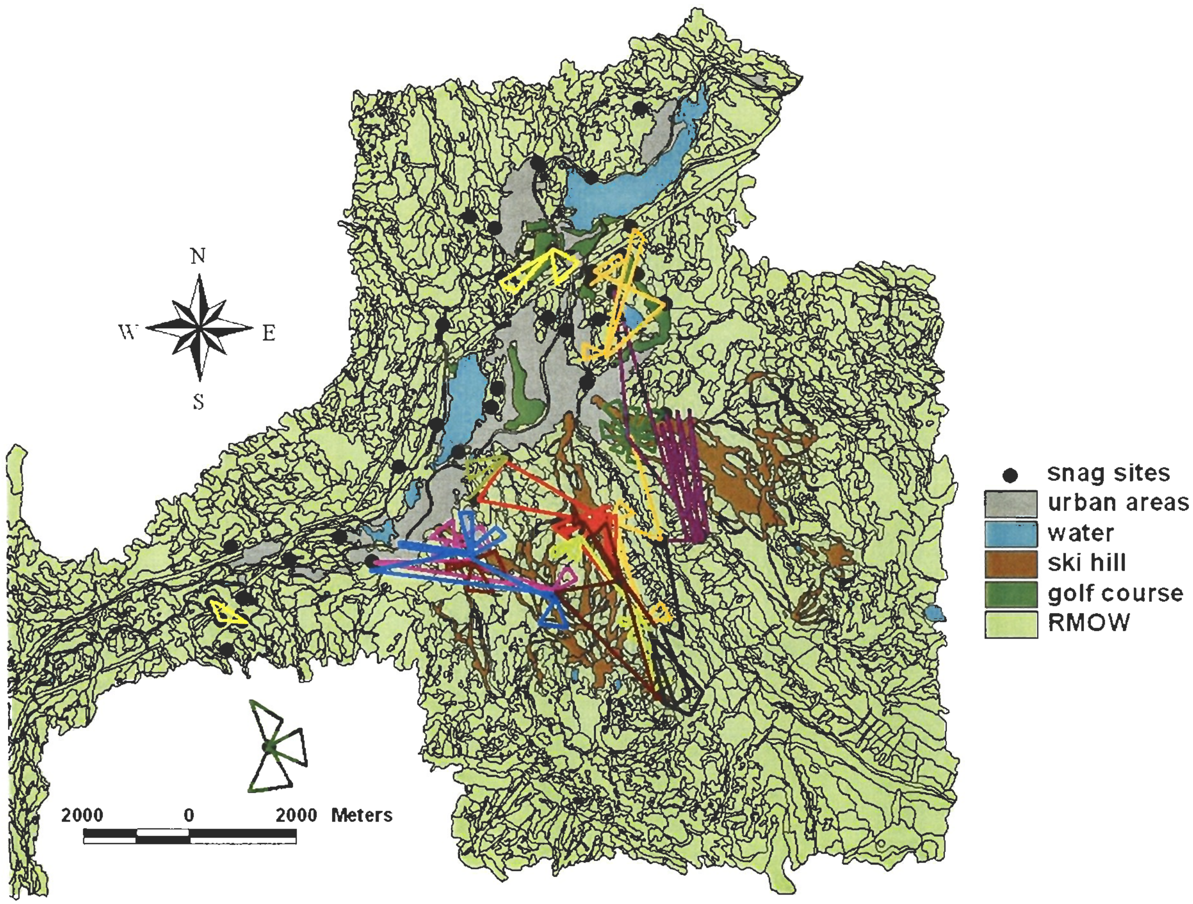


Figure 17. A GIS map which displays each DNA hair snag site that a unique male black bear was identified at three or more times. Each unique bear and the locations in which they were identified at are represented by colour.

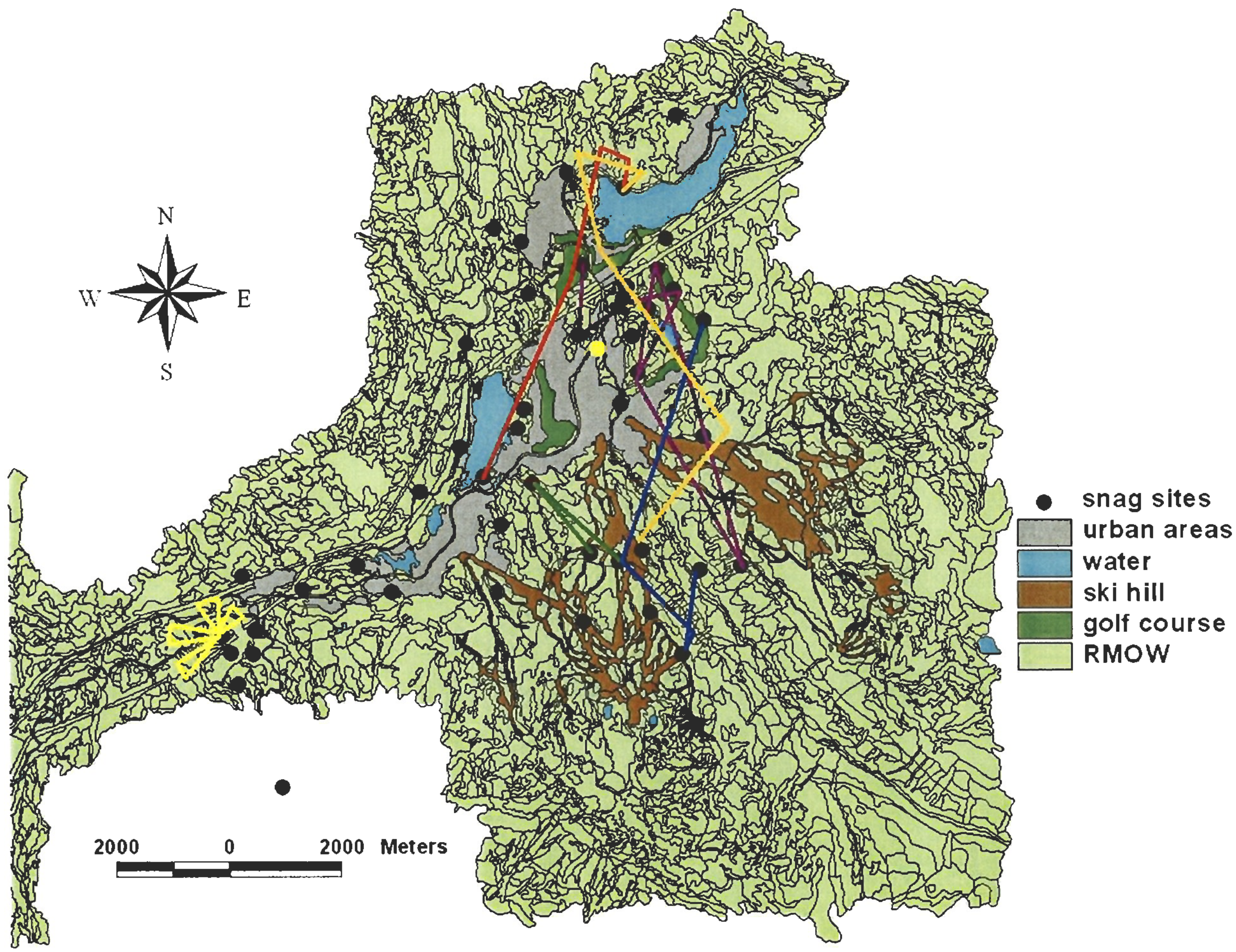


Figure 18. Spatial perspective depicting the spring bear forage habitat values at each of the DNA hair snagging sites within the RMOW.

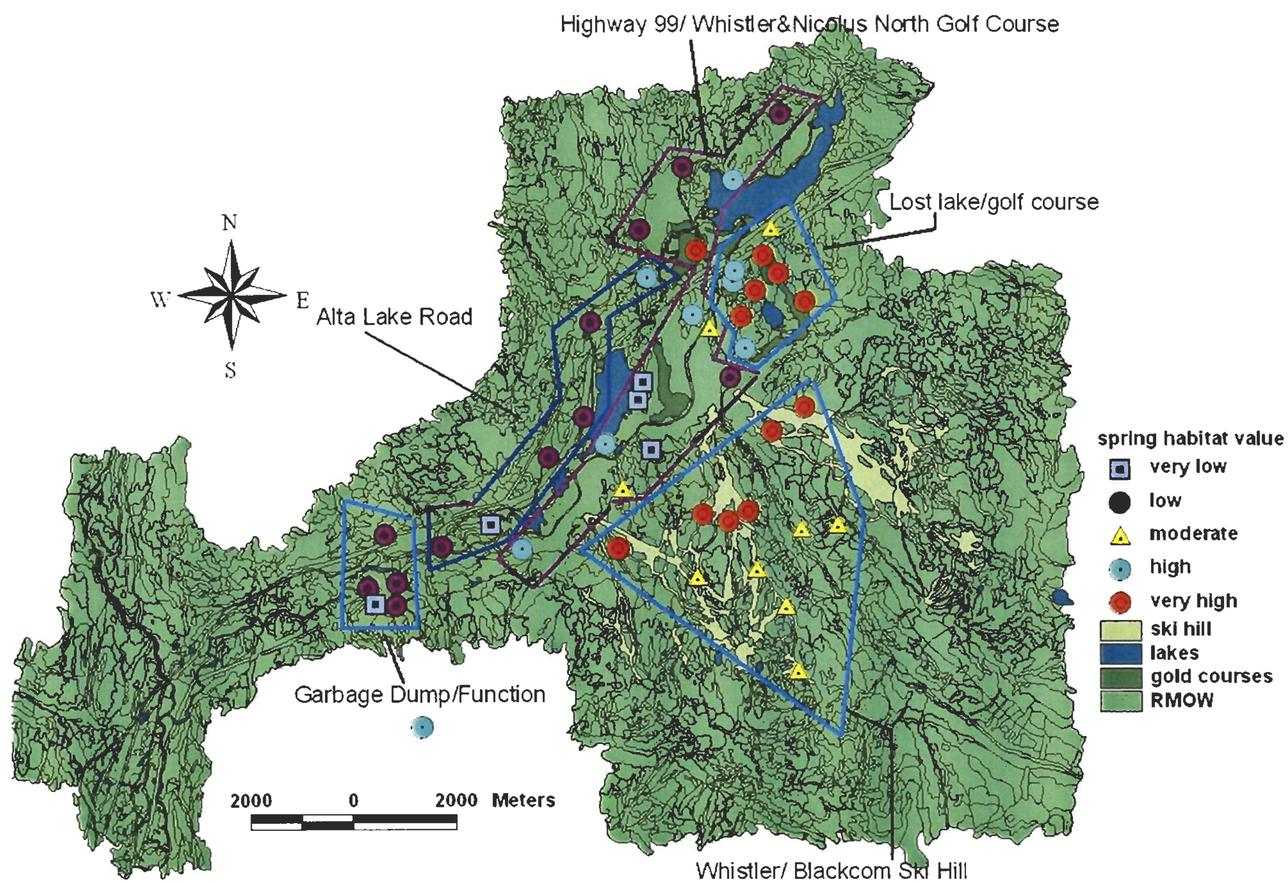


Figure 19. Spatial perspective depicting the summer bear forage habitat values at each of the DNA hair snagging sites hroughout the RMOW.

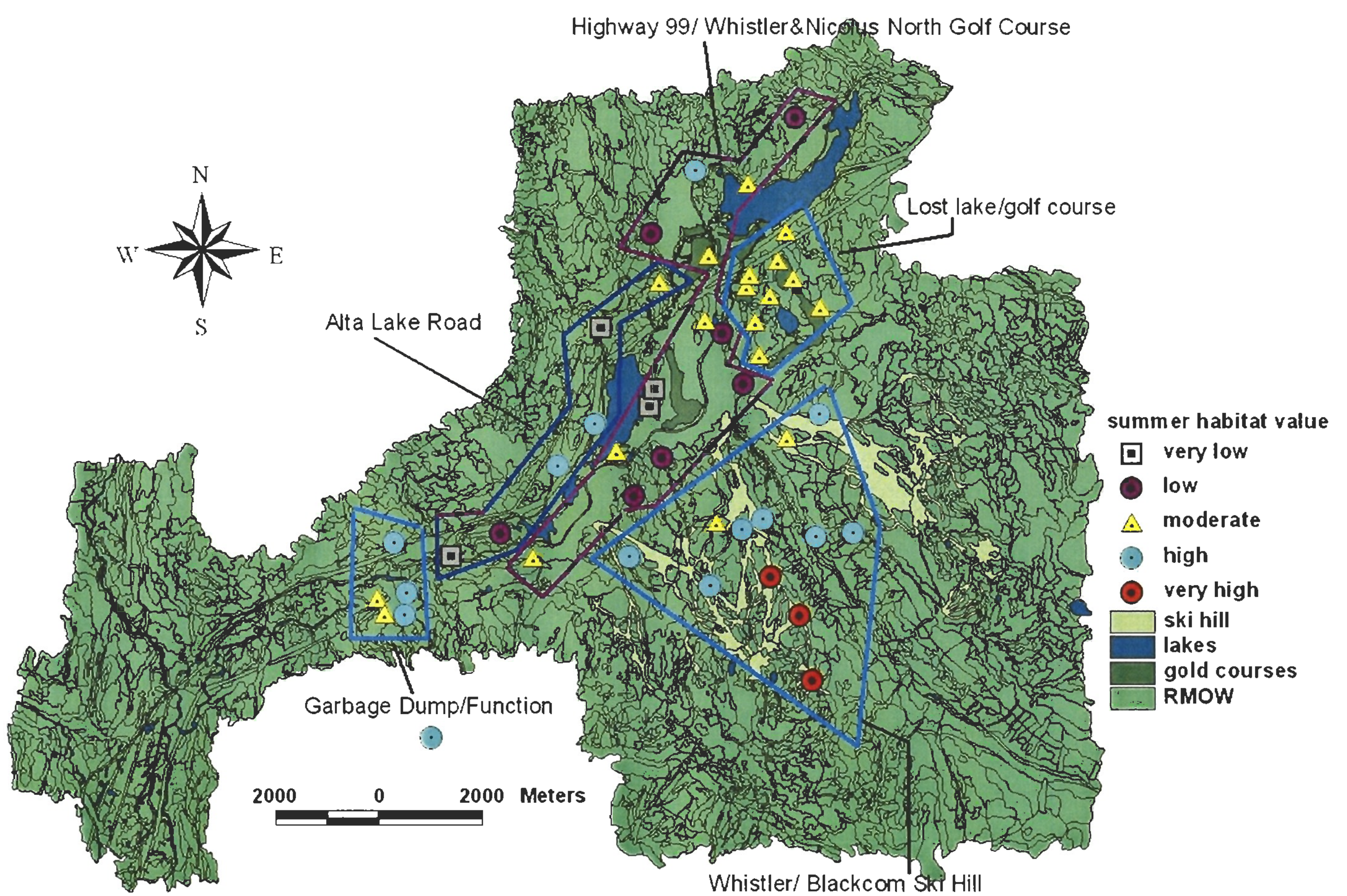


Figure 20. Spatial perspective depicting the fall bear forage habitat values at each of the DNA hair snagging sites throughout the RMOW.

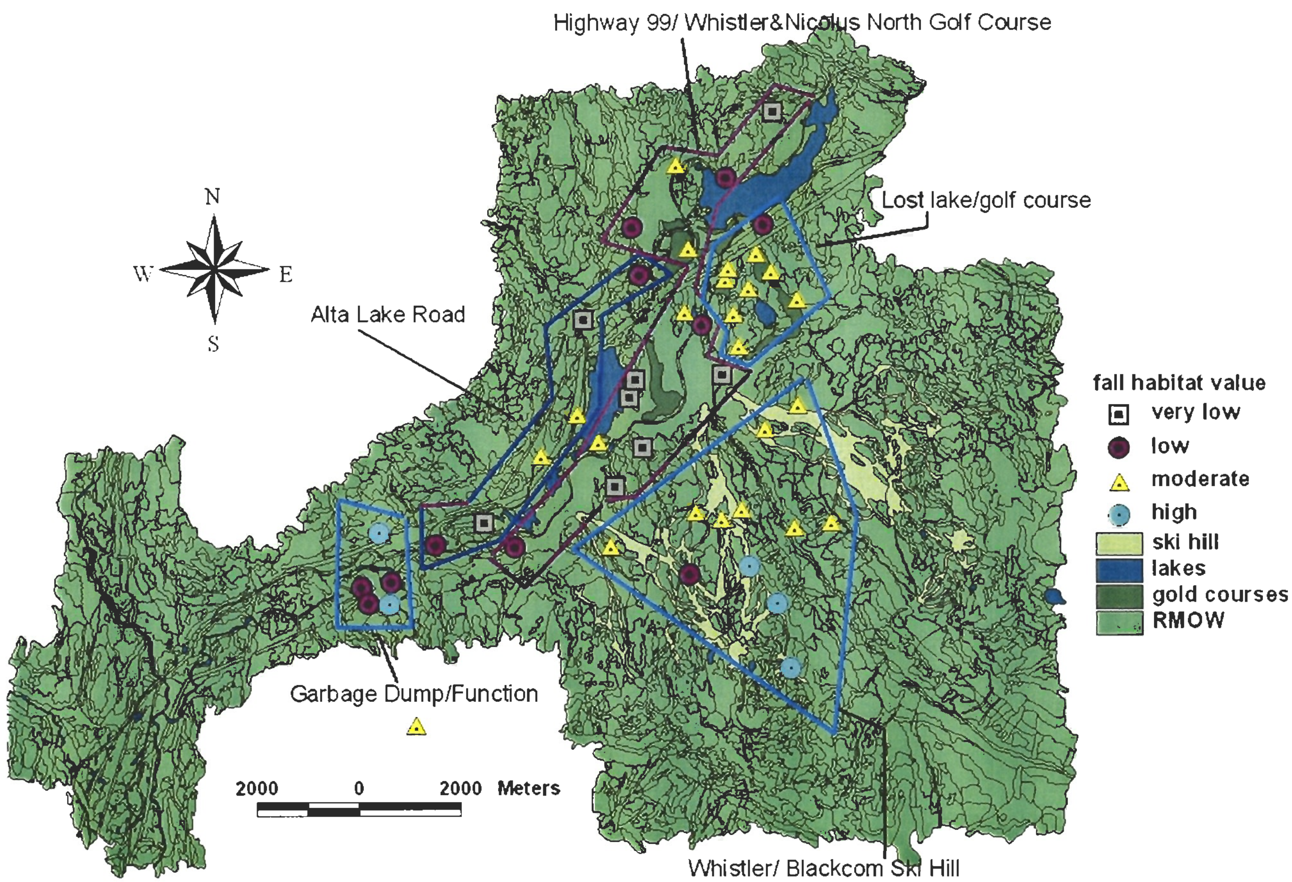


Figure 21. Spatial perspective depicting the number of times bears were identified at each DNA hair snag site, overlaid with the black bear summer forage habitat values within the 250m bufferd hair snagging sites.

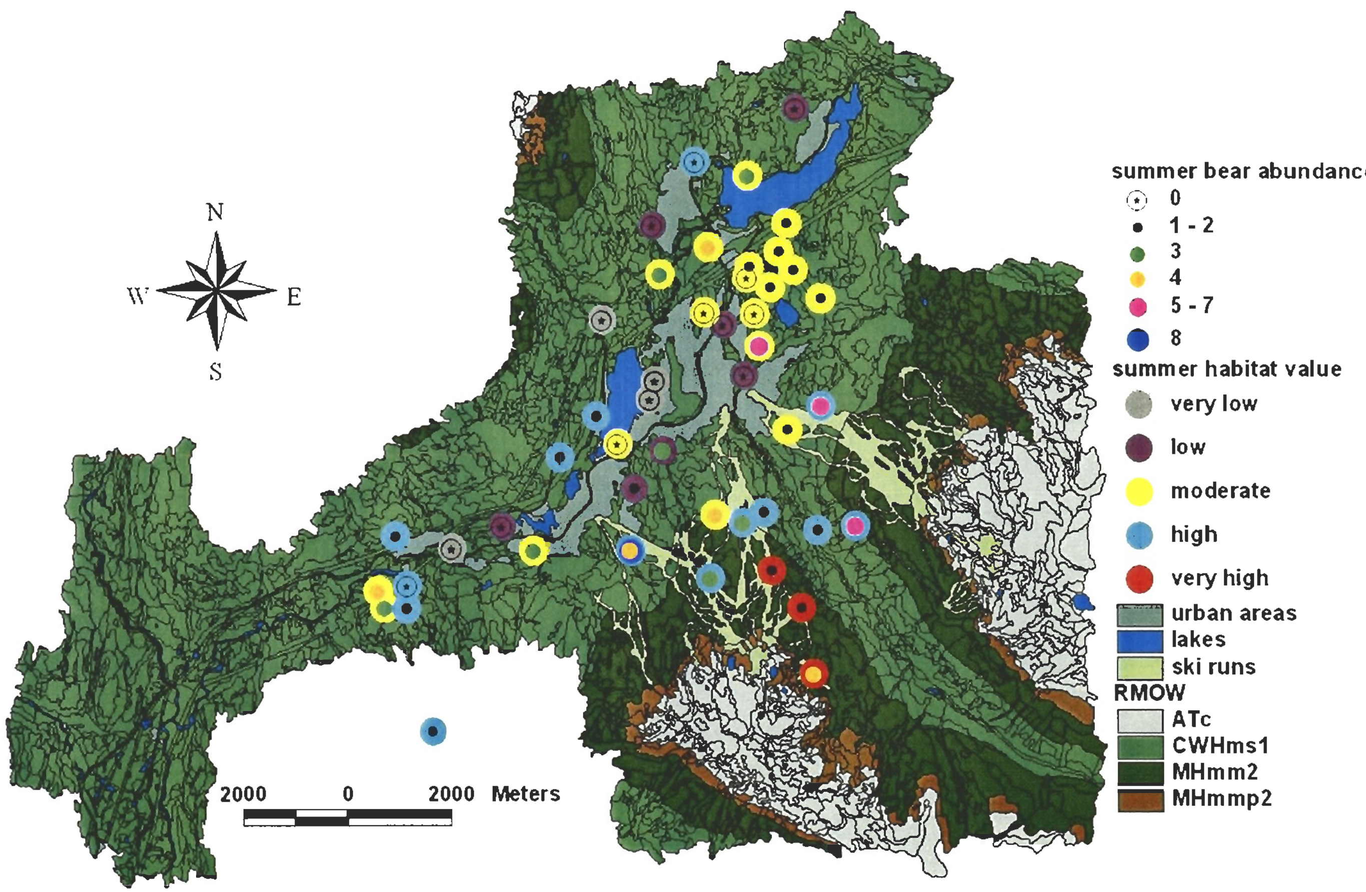
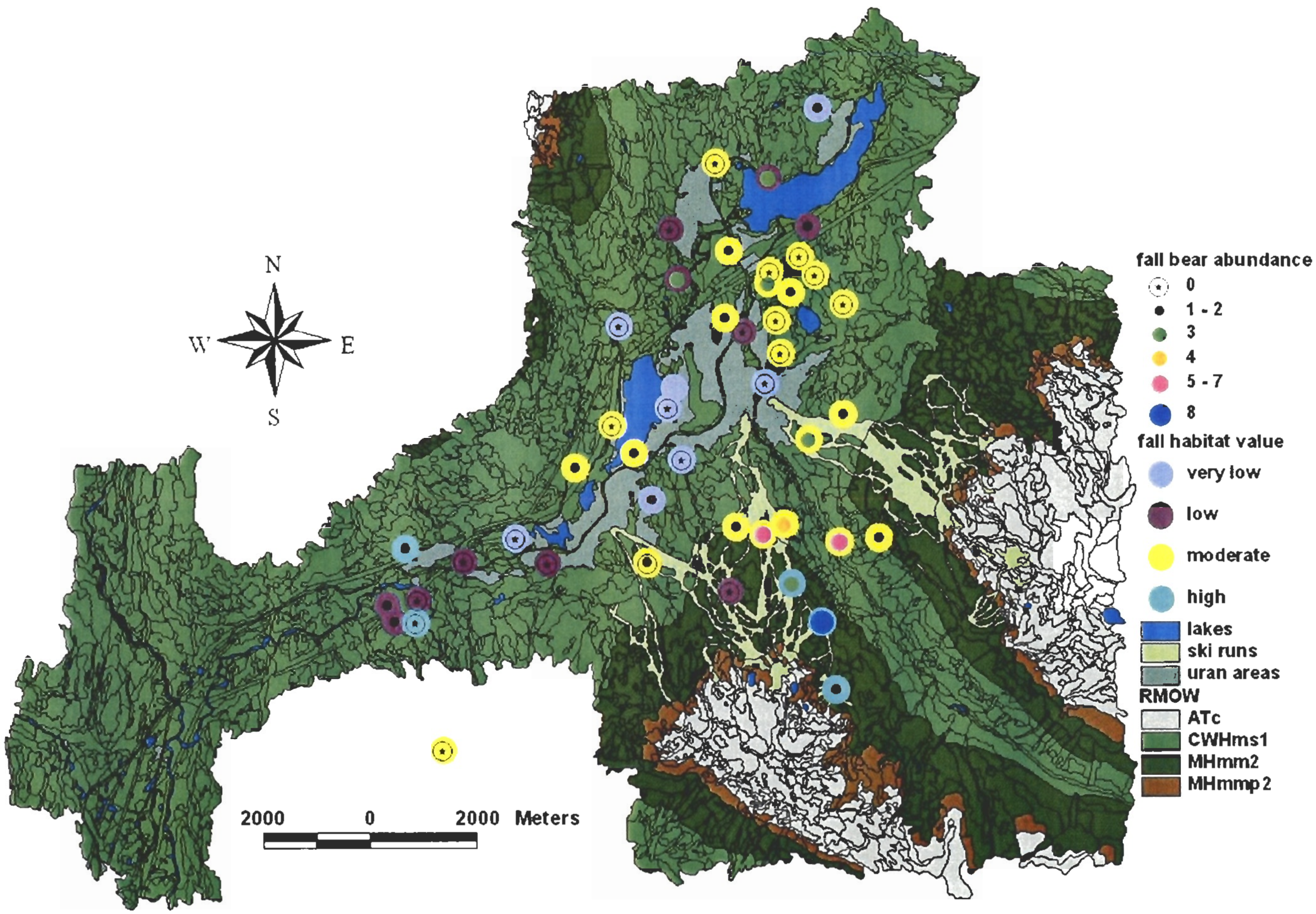


Figure 22. Spatial perspective depicting the number of times bears were identified at each DNA hair snag site, overlaid with the black bear fall forage habitat values within the 250m bufferd hair snagging sites.



APPENDICES

Table A 1. Site series classification including recognized site series in BEC system (Green and Klinka 1994) and site units added by Green (2004) (for TEM mapping).

SITE UNITS

NOTE CODING SEQUENCE:

01-19 : RECOGNIZED SITE SERIES IN BEC SYSTEM (GREEN AND KLINKA 1994)

20-29 : NEW FORESTED SITE UNITS (CWH/MHMM2)

30-40'S: WETLAND UNITS (CWH/MHMM2)

50'S : AVALANCHE TRACKS (ALL BGC UNITS)

60-70'S: ALPINE/PARKLAND UNITS (ATC, MHMMP2)

Code	Site Group	Name	Comments
CWHms1 units			
01	ZO	HwBa – Step moss	slightly dry to fresh/poor to medium sites (zonal)
02	DR	FdPl - Kinnikinnick	very dry/poor sites on bedrock or very thin soils
03	DR	FdHw – Falsebox	moderately dry/poor to medium sites on shallow and/or very coarse soils
04	MR	BaCw – Oak fern	slightly dry to fresh/rich sites
05	MR	HwBa – Queen's cup	moist to very moist/poor to medium sites
06	MR	BaCw – Devil's club	moist to very moist/rich sites
07	FL	Ss - Salmonberry	high bench floodplain sites
08	FL	Act – Red-osier dogwood	medium bench floodplain sites
09	FL	Act - Willow	low bench floodplain sites
10	WE	Pl - Sphagnum	wet/poor sparsely forested bog
11	MP	CwSs – Skunk cabbage	wet/medium to rich sites on poorly drained soils
22	FL	CwSs - Red-osier dogwood - Skunk cabbage	wet/rich sites on poorly drained alluvial soils
23	WE	Cw - Spirea	very wet/medium to rich swamp forest
20	DR	Cw – Fern bluffs	dry to moist/poor to medium sites on forested bluffs and cliffs (extreme microsite variation)

Code	Site Group	Name	Comments
MHmm2 units			
01	ZO	HmBa - Blueberry	fresh/poor to medium sites (zonal)
24	PK	HmYc – Blueberry – Mountain heather	fresh/poor to medium, late snow-lie sites with open canopy forests
25	ZO	Bl-Rhododendron	fresh/poor to medium, warm-aspect sites with strong subcontinental features
02	DR	HmBa – Mountain-heather	slightly dry/poor to medium sites on bedrock or very shallow soils
03	MR	BaHm – Oak fern	fresh/rich sites
04	MR	HmBa - Bramble	moist/poor to medium sites
05	MR	BaHm - Twisted stalk	moist/rich sites
06	MP	HmYc – Deer cabbage	very moist/poor to rich sites with open canopy forests
07	MP	YcHm - Hellebore	very moist/medium to rich sites with open canopy forests
08	MP	HmYc - Sphagnum	wet/poor sparsely forested bog
09	MP	YcHm - Skunk cabbage	wet/medium to rich sites on poorly drained soils with open canopy forests
21	DR	Yc – Rhacomitrium bluffs	scrubby bluff sites
ATc and MHmmp2 units			
60	RO	Penstemon - Juniper	*Dry lithic*: steep lithic sites with talus and rock
61	AK	Bl -Phyllodoce	Dry lithic*: krummholz*
62	PK	Bl – Black huckleberry	*Tree islands*: closed forest stands, generally on steep, snow-shedding slopes
63	AH	Cassiope - Phyllodoce	*Heath*: alpine heather-dominated heath
64	AH	Hm - Cassiope	*Heath*: upper MH heath with dwarf Hm, Bl
65	PK	Parkland - heath	*Parkland*: complex of tree islands with heath matrix
66	PK	Parkland – dry herbaceous	*Parkland*: complex of tree islands with dry herbaceous matrix (Phlox, Pedicularis, Valeriana, etc.)
67	PK	Parkland – lush herbaceous	*Parkland*: complex of tree islands with lush herbaceous matrix (Valeriana, Heracleum, Veratrum, Lupin, etc.)

Code	Site Group	Name	Comments
68	AM	Caltha - Leptarrhena	*Very moist to wet, moisture collecting*: on seepage and moisture collecting sites (encompasses Philonotis order)
69	AM	Valeriana meadows	*Moist to very moist slopes*: lush moist herbaceous meadows
70	WE	Carex - Eriophorum	*Wetlands*: includes the group of sedge/bryophyte communities that occupy water collecting subalpine/alpine basins (Eriophorum order)
71	AM	Carex nigricans	*Snow basins*: encompasses all snow basins; Marsupella included in this complex as it occurs as small depressions in more extensive C. nigricans community.
72	AM	Carex spectabilis	Moist fragmental: *fresh to moist stony sites*
73	AM	Dry herbaceous	*Carex dominated alpine meadows*
NON/SPARSELY FORESTED UNITS			
Wetlands			
30	WE	Ledum-Sphagnum	Bog[1]: *Ledum groenlandicum.-Sphagnum (Klinka* et al *1997)*
31	WE	Myrica-Sphagnum	*Bog*: similar to Carex-Myrica gale (Klinka et al 1997) but more bog-like
32	WE	Carex fen	*Fen*: not specifically in (Klinka et al 1997) but fits in Spirea Order
33	WE	Spirea fen	*Fen*: Spirea douglasii.- Carex sit. (Klinka et al 1997)
34	WE	Juncus-Typha	*Marsh*: close to Juncus ens.-Typha lat. (Klinka et al 1997)
35	WE	Typha	*Marsh*: Typha lat. (Klinka et al 1997)
36	WE	Equisteum	*Shallow water*: very limited; lakeshore fringe
37	WE	Menyanthes	*Shallow water*: similar to Menyanthes-Dulichium (Klinka et al 1997)
38	WE	Nuphar	*Shallow water*: Nuphar poly. (Klinka et al 1997)
39	WE	DrWi-Skunk cabbage	*Swamp*: Lysichitum-Salix (Klinka et al (1997); inundated alluvial site
40	WE	Shrub carr	*Swamp*: not specifically in (Klinka et al 1997) but fits in Spirea Order

Code	Site Group	Name	Comments
Avalanche tracks			
51	AV	Sitka alder – Salmonberry avalanche	shrub dominated avalanche tracks
52	AV	Valerian – Hellebore avalanche	herb dominated avalanche tracks
54	AV	Ba – Copperbush avalanche	young conifer dominated avalanche tracks
55	AV	Brushy talus	talus slopes dominated by shrub species
Non Vegetated			
BU	UR	Buildings, parking, etc.	
CB	SO	Cutbank	
ES	SO	Exposed soil	areas of recent disturbance, such as mud slides, debris torrents, and unspecified human-made disturbances
GB	SO	Gravel Bar	
GC	GC	Golf course	
GL	IC	Glacier, permanent snow	
GP	SO	Gravel pit	
LA	WA	Lake	
MN	RO	Moraine	Recently deglaciated glacial moraine
OW	WA	Shallow Open Water	A wetland composed of permanent shallow open water less than 2 m deep and lacking extensive emergent plant cover (may occasionally dry up)
PD	WA	Pond	A small body of water greater than 2 m deep, but not large enough to be classified as a lake
PL	UT	Powerline	
PN	IC	Permanent snow	
RE	WA	Reservoir	
RI	WA	River	
RN	UT	Railway Surface	
RO	RO	Bedrock	
RV	RO	Bedrock – vegetated	Lichen and bryophyte dominated bedrock in the alpine (e.g. *Rhizocarpon geographicum*, *Umbilicaria proboscidea*)
RU	RO	Rubble	Common in alpine areas, on ridgetops, gentle slopes and flat areas due to the effects of frost heaving
RZ	UT	Road surface	

Code	Site Group	Name	Comments
SF	GC	Sports facilities	
SK	SK	Ski development	
TA	RO	Talus	
TV	RO	Talus - vegetated	Lichen and bryophyte dominated talus in the alpine (e.g. *Rhizocarpon geographicum, Umbilicaria proboscidea.*)
UR	UR	Urban	Residences and other human developments

Table A 2. (a) weighting coefficients used for determining black bear forage habitat values with the ground transects method and site series classification method; (b) season-specific weighting coefficients for each of the site series classifications in the the CWHms1 and MHmm

(a)

Rating Scale for forage habitat values using ground transects method	Rating scale for forage habitat value using the site series classification method	Rating scale used to compare both methods of determing forage habitat values
Very High	60	1
High	50	2
Moderate	40	3
Low	30	4
Very Low	20	5
Iow	10	6
n/a	0	7

(b)

CWHms1				
Hair snagging sites	notes	SPRING	SUMMER	FALL
1	slightly dry pipecleaner moss with summ vac mostly trees and moss	10	30	20
2	very drywestern hemlockmdry w/ lichen b/vacc blueberry some kinnickinick	20	30	40

CWHms1				
Hair snagging sites	notes	SPRING	SUMMER	FALL
3	douglas fir. (mD) red cedar limited oregon grap and blueberry moss cover	10	30	20
4	Very rich (SD) fern/twisted stalk pipecleaner	30	20	10
6	ritch moist red cedar douglsa fir, devils club, fern, twistedstalk, bunchberry,blueberry, some vacc	30	50	40
7	high bentch flood plane salmonberry	40	20	10
8	medium bentch floodplain red osier dogwood	20	30	20
11	wet/medium to rich sites on poorly drained soils skunk cabbage	40	20	10
22	red osier skunk cabbage ritch site poor drain alluvial	30	30	20
23	SWAMP	50	30	20
31	Bog	50	30	20
32	Bog	50	30	20
33	Bog	50	30	20
39	Swamp	50	30	20
40	Swamp	50	30	20
BU	building	0	0	0
ES	exposed soil like mud slides	0	0	0
GB	bravel bar	0	0	0

CWHms1				
Hair snagging sites	notes	SPRING	SUMMER	FALL
GC	golf course	60	40	20
GP	gravel pit	0	0	0
LA	Lake	0	0	0
OW	Open water	0	0	0
PD	Pond >2m	0	0	0
PL	power line	40	60	50
RL	River	0	0	0
RZ	road surface	0	0	0
SF	sports facilities	20	10	10
SK	ski hill	60	40	40
TA	Talus rock	0	0	0
UR	urban	10	10	10

Table A 3. (a) Conversion table to qualitatively describe forage habitat values and to test the correlation between black bear forage habitat values, derived by; seasonal weighting coefficients multiplied by percent area of site series classifications; and, abundance of bear forage species derived by field transects. (b) Results table of season forage habitat values derived using (spring weighting coefficients) * (percent site series classifications), and seasonal descriptive forage habitat values.

(a)

Conversion table	
1 – 10	Very low
11 – 20	Low
21 - 30	Moderate
31 – 40	High
41 - <50	Very high

(b)

Spring forage habitat value		
Hair snag site	(Spring weighting coefficients) * (% site series classifications)	Descriptive forage values
1	16	low
2	10	very low
3	11	low
5	3	very low
6	8	very low
10	10	very low
11	12	low
12	19	low
15	13	low
16	7	very low
17	9	very low
18	10	very low
19	12	low
20	26	moderate
21	30	moderate
22	24	moderate
23	21	moderate
24	27	moderate
25	29	moderate
26	24	moderate
27	13	low
28	31	high
29	26	moderate
30	12	low
31	29	moderate
32	13	low
33	26	moderate
34	33	high
35	29	moderate
36	16	low
38	12	low
39	15	low
40	18	low
41	23	moderate
42	40	high
43	15	low
44	13	low

Spring forage habitat value		
Hair snag site	(Spring weighting coefficients) * (% site series classifications)	Descriptive forage values
45	6	very low
46	13	low
47	12	low
48	18	low
49	12	low
50	17	low
51	15	low

Summer		
Hair snag site	(Spring weighting coefficients) * (% site series classifications)	Conversion of forage values
1	34	high
2	21	moderate
3	26	moderate
5	8	very low
6	25	moderate
10	10	very low
11	29	moderate
12	30	moderate
15	24	moderate
16	13	low
17	22	moderate
18	24	moderate
19	31	high
20	33	high
21	39	high
22	49	very high
23	50	very high
24	49	very high
25	48	very high
26	36	high
27	27	moderate
28	34	high
29	33	high
30	38	high
31	28	moderate
32	12	low
33	33	high

Summer		
Hair snag site	(Spring weighting coefficients) * (% site series classifications)	Conversion of forage values
34	35	high
35	37	high
36	29	moderate
38	29	moderate
39	25	moderate
40	33	high
41	40	high
42	26	moderate
43	25	moderate
44	29	moderate
45	13	low
46	18	low
47	22	moderate
48	26	moderate
49	25	moderate
50	29	moderate
51	34	high

Fall		
Hair snag site	**(Spring weighting coefficients) * (% site series classifications)**	**Conversion of forage values**
1	25	moderate
2	15	low
3	18	low
5	6	very low
6	17	low
10	9	very low
11	20	moderate
12	22	moderate
15	17	low
16	10	very low
17	16	low
18	17	low
19	21	moderate
20	27	moderate
21	32	high
22	40	high
23	40	high
24	39	high

Fall		
Hair snag site	(Spring weighting coefficients) * (% site series classifications)	Conversion of forage values
25	37	high
26	28	moderate
27	17	low
28	28	moderate
29	26	moderate
30	28	moderate
31	18	low
32	10	very low
33	20	moderate
34	20	moderate
35	24	moderate
36	19	low
38	19	low
39	18	low
40	24	moderate
41	32	high
42	15	low
43	23	moderate
44	26	moderate
45	12	low
46	13	low
47	17	low
48	18	low
49	16	low
50	23	moderate
51	24	moderate

Table A 4. Abundance of preferred and occasionally used black bear forage species within the 250 m buffered area surrounding hair snagging sites collected by field transects.

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
1	496960	5548680	Old growth Red Alder and Red Cedar along Miller Creek – 2nd growth closed canopy cedar and mtn Hemlock next to power lines with scattered young cedar	***Miller Creek/*** Elderberry (m) Salmonberry (M) Bitter cherry (T) Vac/red/black (L) Skunk cabage (M) Lady fern (M) Twinberry (L) Mountain Ash (T) ***2nd growth/*** Lady fern (I) ***power Line/*** Vac/red/black (VH) Bearberry (m) Blueberry (M) Salmonberry (H) Bitter cherry (L)	***July 7th 2005*** **1rst scat**/2days old small vac seeds **2nd scat**/weeks old grasses & sedges **3rd scat**/ weeks old grasses **4th**/fresh cub with whole vacc red	The scats were found along the trail beside Miller Creek. The first scat was found 50 feet from the coffee shop in function junction. The third scat was found along the trail along with garbage bags and milk cartons. There was also lots of garbage found along the trail throughout the 250m buffer. No scates were found below the powerline however there were trails and broken brushes throughout the area.
2	497187	5547731	50 year old western hemlocks around 50m buffer of hair snagging sites. Under the powerline are shrubs up to 8m in height. 200 m from hair snagging sites mixed 80 year old to 250 year old mtn hemlocks	**River side** thimbleberyy (m) vacc black (H) skunkcabage (L)		is between road highway garbage dump and cheakamus river and is a fairly moist site

Hair snagging sites #	**Utm**		**Struc.Stage**	**Habitats Descriptors**	**Bear Signs**	**Habitat Comments**
3	496615	5547634	50 to 100 year old western hemlock with the occasional old growth hemlock. Very dry and rock 50m from hair snagging sites	**50m from hair snagging sites** vacc red (L) vacc black (h) **along gravel** lady fern (t) white clover (m) grasses (H) sedges (m) powerlines vacc B (H) blueberry (L) 1	there were many scats around the hair snagging sites along with well used bear trails and day beds.	This hair snagging sites is on top of a rocky steep slope which over looks the garbage dump
5	496750	5547236	little forested area within 250m buffer due to gravel and garbage pit. Hair snagging sites was placed in small patch of 50year old western hemlocks very rock above hair snagging sites	Limited natural food source at hair snagging sites location. Near powerlines are vacc black (m) horsetail, lady fern, grasses, sedges and clover along road side and near dump		This is a very un natural location for a hair snagging sites there is relatively high amounts of fruits outside of the 250m buffer but not within
6	497160	5547309		limited	No signs	
8	497653	5544976	mixed old growth and second growth western hemlock	limited	No signs	
9	498059	5548436	alder mixed with cedar and western hemlock very moist area with closed canopy and moss covered floor forest is 80-150 years old with a few mixed old	**50m from hair snagging sites** Vacc black (m) skunkcabbage (l) devils club (l) Grasses, sedges (m) clover (m) bog blueberry **powerlines** vacc (H) blueberry (M) bittercherry (T) rasberry (L) thimbleberry (L)	no bear identification was determined at this hair snagging sites however in late July a scat was observed	it is very moist near the hair snagging sites site with small pounds nearby. The ground was difficult to walk on without getting feet soaked so the food listed were scattered around based on the location of the small ponds

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
			growth cedar and hemlocks			
10	499400	5548960	50 meter perimeter of hair snagging sites near closed canopy - 100-150 years old trees not a lot of ground cover mostly moss 100-200 meter from hair snagging sites rocky talus steep slopes with power lines. Dry with mtn hemlock and cedar nearer to hair snagging sites	Vacc/black patchy (H) Vacc.red patchy (L+) Salmonberry (L) Elderberry (T)	***July 7th 2005*** ***1rst scat/*** old mostly grasses/sedges ***2nd scat/***fresh with grass & vacc red and black	No individuals were found however, there were sings in July as signs were torn down and chewed and scat was found inside hair snagging sites in late August

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
11	499612	5548236	The area around the hair snagging sites was mostly western hemlock 100 to 200 year old with the occasional old growth. The canopy was closed with a mossy ground cover. There were some old growth western hemlock and cedar near the pond.	**forested area** blue berry (M) Vacc black (L) Bunchberry (M) lady fern (L) skunkcabbage (T) red alderberry (L) **along graavel road and valley trail and pond/playground** devils club (L) skunkcabbage (H) Grasses/sedges (H) Fireweed (H) alderberry (M) thimbleberry (M) horsetail (H) blackberry (L) Vac red/black (M)	June 27 2005 5 fresh scats were found beside the playground along the valley trail and gravel road	The hair snagging sites is very near a urban development as many of the houses back onto the valley trail
12	501496	5548405	second growth western hemlock within 50m buffer of hair snagging sites. 200m from hair snagging sites is mixed old growth hemlock and some yellow cedar with some 100-250 year old stands -some amabilis fir	ski trails grasses (m) Pink clover (Vh) Sedges (M) Rasberry (L) white clover (l) Near River devils club (H) Skunk cabage (L) black current (H) Vacc black (H) thimbleberry (M) Old growth Vacc black (M) Vacc red (M) Lady Fern (L) Blue berry (L)	July 15 one fresh scat with vacc seeds and grasses	this is a very common location to see bears this week there was record that a bear two bears were walking around this ski slope and tipped over garbage cans at the ski club building not to far away. There is also a lot of garbage in this area probably one of the highest concentrations of garbage in Whistler excluding the dump
13	501476	5548424	the same as 12	the same as 12	the same as 12	the same as 12

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
15	501565	5549576	old growth hemlock and cedar around hair snagging sites with areas of 80 to 200 year old stands some of the areas near the tennis court are second growth 50 year old with total canopy closure	Near tennis court /road horsetail (VH) devils club (M) grasses (VH) rose (M) lady fern (M) skunk cabbage (L) twisted stalk (M) bunch berry (H) dandelion (H) Vacc (L) hellebore (L) white clover (M) red elderberry (T) Forested area Vac black (H)	June 25 two scats were found a few meters from the tennis courts. A day bed was also found 2 meters from the parking lot with a scat beside it.	This area has some good habitat however it is also very steep and rocky mixed with old growth forest. There is a small stream that runs into valley beside the tennis courts that has high habitat value. Most of the good habitat run alongside the main road into this area
16	501240	5550440	Mature forest hemlock with developed understory with some older cedars	Vacc. Black (H) Vacc. Red (m) Red raspberry (M) blueberry (M) skunk cabbage (l) horsetail (H) near lake and road red elderberry (M) Thimbleberry (H) Lady Fern (M) devils club (M) Twisted stalk (M) Twinberry (L) Rose (T)	May 27 saw bear and scat and July 20 saw scat	This is a small area surrounded by urban development and lake it become steep and rock towards the lake shore but the understory is fairly dense
17	501871	5551287	80 to 200 year old stand with closed canopy and mossy understory. Limited shrubs	vacc. Black (l) vacc. Red (T)	No signs	People have seen bears in this are but there has never been anything within the 250m buffer.

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
19	502120	5550320	around the hair snagging sites are 80 250 yr old hemlocks and yellow cedar. 200m from hair snagging sites patches of old growth. The entire forested buffered area has poor understory with a mossy ground cover and very few shrubs. Very rocky in areas with open areas with the occasional old growth tree.	Vacc. Black (T) vacc. Red (T) blueberry (T) lady fern (T)	July 10 2 small scats near hair snagging sites	this area has some high quality habitat areas ,however they are small patches with extremely poor habitat dominating the area
20	504018	5549136	Areas of second growth hemlock and fir and patches of old growth hemlock and the occasional D. fir major areas of pipemoss ground cover nearly closed canopy. In some areas south of the hair	vacc black -M vacc red- trace blueberry - low clover along ski run -H grasses and sedges along ski run and nearby roads H	50m from hair snagging sites scat I week old with small seed old scats to the west of the hair snagging sites 50m with mostly grasses there are many bear trails heading south west into the second growth where there is a lot of vacc.	This seems to be a well used area as there are many bear signs such as marked tress, pathways, dug holes and scats.

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
			snagging sites it is very steep and rocky			
21	503622	5548942		ski trail grasses m clover h forested area black vacc h	No signs	
22	504160	5548040		ski trail grasses m clover h forested area black vacc h	No signs	
23	504720	5547320	mountain hemlock with amabilis fir old growth, south west side is more closed	ski trail grasses m clover h forested area black vacc h	No signs	
24	504960	5546080	some old growth mtn hemlock south of hair snagging sites mixed with areas of second growth hemlock. Due to ski runs there is a lot of cleared area as there are many ski runs joining	along/around hair snagging sites and alpine stream hellebore - low bramble berry - M white rhod. H horse tail - H grasess/sedges - high vacc. black forested areas closed canopy with large wildlife trees for denning vacc. black low blueberry T grasses/sedges/horsetai l along ski runs H	1 old grassy scat in area	it was very wet around the hair snagging sites due to an alpine stream. There was very little forest cover within 100 m of the hair snagging sites as a result of all of the merging ski runs

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
25	503000	5547880	this is the next bec zone 80-250 mountain hemlocks, yellow cedar, amabilis fir	along ski hill grasses (VH) horsetail (m) clover (H) forested area white rhodo. (H) Vacc (L) some wet areas hellebore (M)	old scat July 15 old and mostly grasses	July 15th there were very few berries on the vacc. They were just starting to come out and were small and g
26	503120	5549080	old growth mountain hemlock some western hemlock , cedar, and amabilis fir	Vacc. Black (M) blueberry (T) grasses along ski hill (H) along with clover and horsetail, thimbleberry (M) fireweed (M)	No signs	berries were not ripe yet and grasess were turning yellow
27	505040	5548800	25 to 50 year old western hemlocks and cedar	vacc. Black (M) Mossy ground cover Vacc. Red (L) Lady fern (T) Grasses/horse tail along gravel road	No signs	
28	504474	5550696		ski trail grasses m clover h forested area black vacc h	No signs	
29	505120	5551160		ski trail grasses m clover h forested area black vacc h	No signs	
30	505760	5548880	mostly old growth mountain hmlock with mixed 80 - 200 year old hemlock and cedar with (M) amabilis fir	ski trail grasses m clover h forested area black vacc h	No signs	

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
31	504360	5552240	25 -80 year old hemlock and cedar	50 m from hair snagging sites vacc red (T) Vac black (M) along the river very moist areas with skunk cabage (M) Horsetail and grasses (H) devils club (L) fern (L) thimbleberry (M) elderberry (L) false solomons seal (T)	No signs	
32	503271	5552707	old growth western hemlock	along road side Fire weed (H) clover (M) Grasses (H) horsetail (H) Skunk Cabage (M) elderberry (M) Thimble berry (M) Devils club (T) In forest Vacc. black (T) vacc. red (T) Fern (L)	No signs	oct 3 2003 a sample was taken from the hair snagging sites but was mixed
33	505127	5553211	old growth western hemlock mixed with cedar	golf course - grasses clover, horsetail sedges forested area vac. Red/black (M) thimbleberry (L)		GOLF COURSE
34	504612	5553757	young forest 25-80 year old hemlocks	golf course - grasses clover, horsetail sedges forested area vac. Red/black (M) thimbleberry (L)		GOLF COURSE
35	504329	5554109	young forest 25-80 year old hemlocks	golf course - grasses clover, horsetail sedges forested area vac. Red/black (M) thimbleberry (L)		GOLF COURSE

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
36	504163	5553426	mature forest patches of forested area. Hemlock, spruce, cedar, white pine	wetlands near hair snagging sites Skunk cabbage (VH) Devils club (H) around marsh area Elderberry (H) Horsetail (H) Grasses H) Sedges (H) red O. dogwood (M) Thimbleberry along road side (VH) Forested area Vacc black (VH) Vacc. red (L)	No signs	
37	503966	5552292	mature forest Hemlock, spruce, cedar, white pine	bearberry (H) vacc. Black (H) blue berry (M) along the road Clover pink (M) horsetail (M) thimbleberry (M) small patch of wetland devils club (T) Skink cabage (M)	July 10 three scats one old one mostly grasses and two new ones with lots of vacc. Black seeds	this area is dry and very rocky with a moss ground cover there are a few pockets of wet bog areas with high amounts of bear foods
38	503884	5552921	mature forest Hemlock, spruce, cedar, white pine	bearberry (H) vacc. Black (H) blue berry (M) along the road Clover pink (M) horsetail (M) thimbleberry (M) small patch of wetland devils club (T) Skink cabage (M)	No signs	
39	503731	5553604	mature forest mostly hemlock with some cedar and spruce	Dry rock area bearberry (H) thimbleberry mostly along the road (M) Vacc black (M) blueberry (L) elderberry (T) red O. dogwood (L) below wetland area twisted stalk (M) Skunkcabbage (VH) devils club (L) hookersbell (L)	No signs	

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
40	503778	5553814	old growth mixed with mature forest mostly hemlock with some cedar and spruce	Dry rock area bearberry (H) thimbleberry mostly along the road (M) Vacc black (M) blueberry (L) elderberry (T) red O. dogwood (L) below wetland area twisted stalk (M) Skunkcabbage (VH) devils club (L) hookersbell (L)	No signs	
41	504484	5554652	old growth with100-200 year old forest hemlock cedar some spruce	dry rock ridge with hair snagging sites bearberry (M) Vacc. (M) near powerlines Vacc black (H) raspberry (L)	No signs	
42	502920	5554520	small patch of old growth forest surrounded by urban dev. Roads and mostly golf course	horsetail (VH) Rose (M) thimble berry (VH) red o. dogwood (M) elderberry (L) fireweed (H) grasses/sedges/dandelions along the golf course and parking lot (VH)	there is always a scat in this area especially in later spring and summer	this area sees a lot of activity and when I was last there they had developed this patch more as it is part of the golf course
43	502935	5552949	25-80 year old forest	vacc black (M) around wetland rose (M) raspberry (L) skunk cabbage (M) Blue berry (L) twisted stalk (M) elderberry (L)	No signs	this area is a bog behind nesters has good habitat close to pond and within 100m
44	504670.3	5556845	100 to greater than 250 with hemlock 50m from hair snagging sites is closed canopy with mossy ground	Vacc. Black (L) around the pond there is clover, grasses, horsetail	I never saw any scats around this are	there were many different samples of hair in the hair snagging sites that were reddy brown and could have been dog.

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
			cover			
45	503753 .8	5555565	100-250 year old forest patch closed canopy with mossy understory	Vacc. Red (M) Vacc. Black (H) north of hair snagging sites Bearberry (H) grasses (L)	during the sample season there were many young scats and the rope was constantly pulled down but there was not always hair samples I think they were climbing over the tree.	there is an old squatters residents in the trees 50m from the hair snagging sites and a ton of garbage sorrounding the area with lots of bite marks
46	502768 .8	5555830	Moderately closed canopy with scattered large areas of tree fall open areas 10-20m wide X 50m long. Varying str. Stage 20yrs to 250yrs mnt Hem. and D.Fir. Areas with closed canopy limited understory vacc and lady fern Open areas - new white pine	***50m from hair snagging sites*** vacc red (L) vac black (T) lady fern (T) ***Along roadside and trails*** white clover (L) Grasses (M) Dandelions (M) thimble berry (T) ***Open tree fall areas*** Vacc black (VH) Vacc red (H)	July 7th 2005 Small subadult was seen walking through tree fall area	Hair was found here in August but was not enough to extract DNA. There was also a lot of red dog hair found through out the entire sampling season. Old squatters residences are scattered around the closed canopy forest along with major bike trials. The bike trails have large bike jumps and ladders. While walking through the forest every 50m there is another trail.
47	501936 .8	5554609			No signs	
48	502059	5553772				

Hair snagging sites #	Utm		Struc.Stage	Habitats Descriptors	Bear Signs	Habitat Comments
49	500956	5552979	West side Closed canopy no understory 20-50 yrs east side of hair snagging sites more open canopy with 20-80 yrs trees moderate ground cover dry and rocky near road side	***Along the gravel road*** Grasses (H) Dandelions (M) thimble berry (L) Bearberry (M) White clover (H) Dewberry (T) ***50 m around hair snagging sites*** Vac R&B (L)	Never seen any signs of bears in this area	there have never been any signs of bears in this area however a few hundred meters from the hair snagging sites site is 21 mile creek which is high in bear foods and there have been many sightings in this area.
50	500834 .3	5550960	old growth forest around hair snagging sites between powerlines on one side and a road urban and lake on the other side	***Forested area*** vacc. Red (M) vacc. Black (L) Lady fern (T) ***Power line*** Vac/red/black (H) Bearberry (H) Blueberry (M) Salmonberry (m) Bitter cherry (L)		
51	500200	5550200	Moderately closed canopy western Hem. and D.Fir closed canopy near stream 50m from hair snagging sites site	***Along road side*** Hair snagging sites side is steep and rocky with vacc red (L) Across the road is wet with thimble berry (L) Skink Cabbage (L) Mountain ash (L) dwarf blueberry (T) 50 m from hair snagging sites vacc/red/black (L) Lady fern (L) Thimble berry (L)	July 7 2005 Large black bear was seen across the road 50meter from the hair snagging sites. He came across the road and walked into an open areas high with Vac red	During the sample session there was a lot of construction and blasting taking place in July and August.

Table A 5. Season black bear forage habitat values derived from field transects at hair snagging sites.

Hair snagging sites	Spring forage habitat value	Summer forage habitat value	Fall forage habitat value
1	2	4	4
2	2	4	2
3	2	3	2
5	1	3	2
6	2	4	4
8	4	5	3
9	2	1	2
10	1	2	1
11	4	3	2
12	5	4	3
13	5	4	3
15	3	2	1
16	4	3	3
17	1	1	1
18	1	1	1
19	1	2	1
20	5	4	3
21	5	4	3
22	3	5	4
23	3	5	4
24	3	5	4
25	3	4	2
26	5	3	3
27	3	4	3
28	5	3	3
29	5	4	3
30	3	4	3
31	2	2	1
32	3	2	2
33	5	3	3
34	5	3	3
35	5	3	3
36	5	3	3
37	4	4	3
38	5	3	3
39	4	3	3
40	4	3	3

41	3	3	2	
42	5	3	3	
43	4	3	3	
44	2	2	1	
45	4	3	2	
46	2	4	3	
47	2	2	2	
48	4	3	2	
49	2	1	1	
50	2	4	3	
51	2	4	3	

Table A 6. Results of DNA hair analyzes from Wildlife Genetics, Nelson British Columbia including hair collected during preliminary study 2002 indicates as captures in set A. Captures in sets B and C are from 2003.

Individual	# Samples	Sex	Captures in Set A	Captures in Set B	Captures in Set C
A2	37	F F	A2; A7; A25; A26; A56; A57; A80; A81; A45; A52; A59;	B101;	C14; C16; C64; C68; C75; C191; C206; C221; C224; C226; C229; C231; C232; C234; C236; C239; C241; C243; C247; C251; C253; C255; C260; C262; C264;
A5	6	M M	A5; A27; A70;	B44;	C17; C25;
A8	1	M	A8;		
A9	1	M	A9;		
A11	10	M M	A11;	B40; B59; B77; B88;	C1; C2; C3; C4; C5;
A13	2	M	A13; A18;		
A15	1	M	A15;		
A16	3	F	A16; A17; A22;		
A19	18	F F	A19; A60; A66; A86; A47;	B42; B68; B70;	C141; C157; C198; C199; C223; C266; C268; C269; C278; C279;
A21	3	M	A21; A42; A83;		
A24	1	M	A24;		
A28	1	M	A28;		
A31	5	F F	A31; A32;	B100;	C15; C109;
A33	14	F F	A33; A34; A49;	B7; B9; B10; B11; B13; B20; B29; B33; B106;	C26; C213;
A35	4	M	A35; A54; A55; A71;		
A36	8	M M	A36; A37; A39;	B15;	C164; C173; C175; C211;
A41	2	F	A41;	B105;	
A43	1	F	A43;		
A62	18	F F	A62; A65; A73; A75; A79;	B27; B41; B72;	C19; C22; C113; C135; C138; C140; C193; C204;

Individual	# Samples	Sex	Captures in Set A	Captures in Set B	Captures in Set C
			A84; A87;		
A64	12	F F	A64; A68; A76; A85;	B25; B37; B50;	C72; C73; C114; C147; C195;
A67	5	F	A67; A72;	B60; B65; B86;	
A77	12	F F	A77;	B76; B82;	C20; C53; C55; C56; C58; C60; C105; C106; C143;
A78	3	M	A78;	B21; B34;	
B8	4	F F		B8; B89;	C6; C216;
B14	4	F	A74;	B14; B55; B56;	
B17	5	M M		B17; B39;	C93; C110; C306;
B32	18	F F		B32; B36; B47; B48; B108; B109;	C27; C29; C32; C77; C78; C80; C81; C83; C122; C179; C275; C276;
B38	1	M		B38;	
B43	3	F F		B43;	C12; C104;
B46	1	F		B46;	
B53	10	F F		B53; B78;	C35; C36; C84; C123; C129; C181; C184; C214;
B58	1	F		B58;	
B62	3	M M		B62;	C145; C203;
B75	8	M M		B75; B90; B91; B99;	C11; C63; C65; C66;
B81	2	M M		B81;	C38;
B95	8	M M		B95;	C33; C82; C86; C125; C182; C186; C311;
A46	2	M M	A46;		C296;
C8	3	F			C8; C50; C134;
C9	1	F			C9;
C10	1	F			C10;
C13	2	M			C13; C102;
C39	2	F			C39; C91;
C41	7	F			C41; C87; C88; C95; C96; C131; C132;
C42	2	M			C42; C43;

Individual	# Samples	Sex	Captures in Set A	Captures in Set B	Captures in Set C
C44	2	F			C44; C45;
C71	1	M			C71;
C97	1	F			C97;
C98	3	F			C98; C100; C160;
C121	6	F			C121; C151; C153; C171; C197; C208;
C136	1	M			C136;
C149	2	M			C149; C209;
C189	2	M			C189; C190;
C245	2	F			C245; C257;
C248	3	M			C248; C281; C284;
C271	1	F			C271;
C286	2	M			C286; C297;
C287	5	M			C287; C288; C289; C290; C295;
C300	2	F			C300; C302;
C305	1	M			C305;

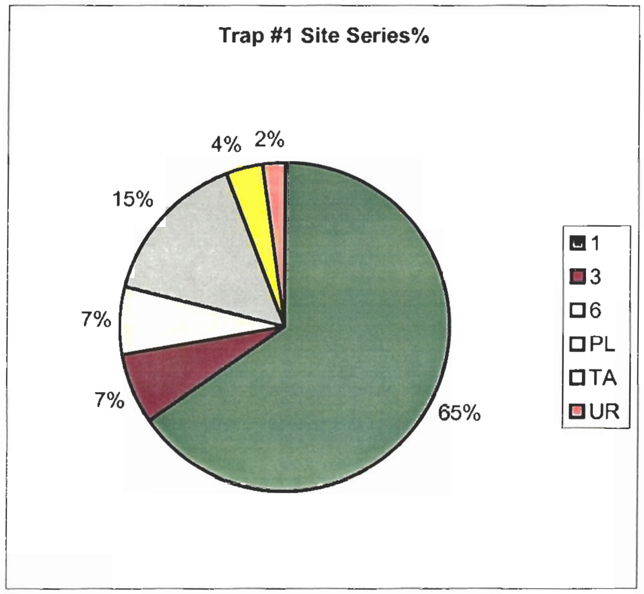
Table A 7. Results of DNA hair analyzes from Wildlife Genetics International, Nelson British Columbia including the list of all individuals identified during 2002 and 2003.

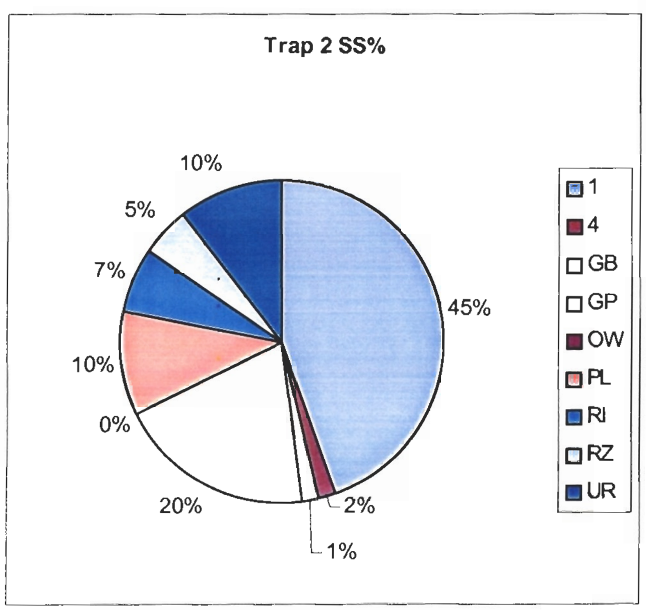
Individual	# Loci	*G1A*	*G10B*	*G10J*	*G10L*	*MU59*	*G10X*	Similar Genotypes
A2	6	194.196	160.162	201.207	159.159	231.243	145.147	
A5	6	196.198	158.162	201.205	159.165	231.241	129.147	
A8	6	184.192	160.160	187.207	135.149	239.243	149.161	2MM:C245;
A9	6	192.192	158.158	187.205	135.159	231.243	147.149	
A11	6	192.198	160.160	205.205	151.159	237.237	145.147	
A13	6	184.194	158.160	201.205	135.159	237.241	121.147	
A15	6	184.192	156.164	199.207	159.159	243.245	147.149	
A16	6	192.194	156.162	187.199	159.159	231.243	147.149	
A19	6	194.198	160.164	197.205	151.159	241.241	149.149	
A21	6	194.196	158.160	199.201	159.161	237.243	129.149	
A24	6	194.198	160.160	197.203	135.135	237.243	147.149	
A28	6	194.200	156.166	187.187	135.159	241.241	121.149	
A31	6	194.196	158.162	201.205	159.161	231.243	129.147	
A33	6	192.196	162.162	201.207	159.171	231.245	145.149	
A35	6	190.200	160.160	197.207	135.137	237.243	149.161	2MM:C71;
A36	6	196.198	160.164	201.205	159.167	239.241	127.161	
A41	6	196.198	160.164	197.199	151.161	241.243	149.149	
A43	6	192.196	160.160	187.207	135.151	241.241	149.149	
A62	6	192.194	156.160	201.207	159.167	237.237	149.149	
A64	6	192.192	160.164	201.205	135.159	233.239	139.149	
A67	6	192.200	156.160	187.187	135.159	237.241	121.149	
A77	6	184.194	160.164	191.207	137.151	231.241	129.147	
A78	6	192.196	160.164	205.207	159.159	231.231	147.149	

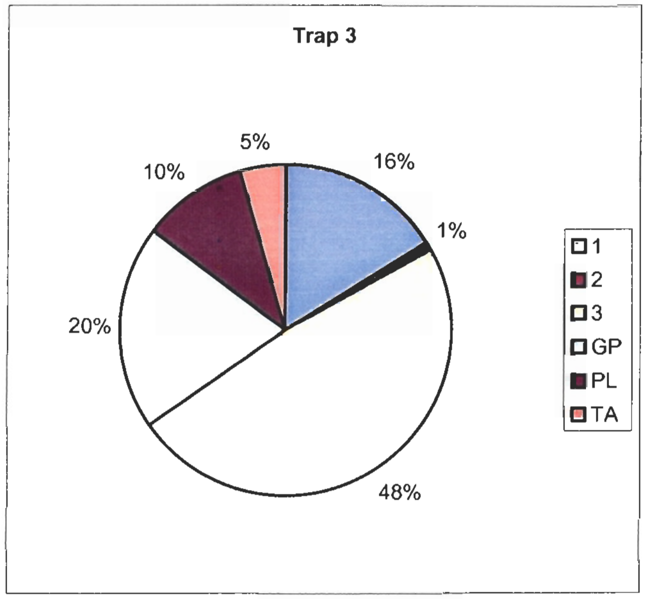
Individual	# Loci	*G1A*	*G10B*	*G10J*	*G10L*	*MU59*	*G10X*	Similar Genotypes
B8	6	192.198	160.164	205.205	151.167	237.247	149.149	
B14	6	198.198	158.164	205.205	165.167	237.247	147.149	
B17	6	190.196	158.166	199.205	161.161	241.243	147.149	
B32	6	194.196	160.162	201.205	135.159	237.241	129.149	
B38	6	192.194	160.160	187.203	159.171	241.245	129.131	
B43	6	194.198	160.164	191.199	151.161	241.243	129.147	
B46	6	194.198	160.166	201.205	135.135	231.239	149.149	
B53	6	184.194	156.160	199.205	135.161	239.243	149.149	
B58	6	192.192	158.160	205.207	159.167	237.243	145.149	
B62	6	190.200	160.166	187.201	159.171	237.237	149.151	
B75	6	190.192	160.162	187.207	151.159	237.243	149.151	
B81	6	192.194	158.162	201.207	151.159	237.239	129.149	
B95	6	190.194	160.162	197.201	135.159	239.241	129.147	
A46	6	194.196	162.162	199.201	159.159	237.239	127.129	
C8	6	190.198	158.160	201.205	159.165	243.243	147.149	
C9	6	192.192	160.160	197.205	159.169	231.243	145.145	
C10	6	192.200	160.164	201.203	159.159	231.243	127.149	
C13	6	192.198	156.160	187.201	135.137	233.237	121.127	
C39	6	194.198	158.166	205.207	135.159	237.239	145.149	
C41	6	192.192	160.160	187.201	135.159	239.241	141.147	
C42	6	192.192	156.160	187.201	159.159	241.245	145.147	
C44	6	194.198	160.164	187.205	161.165	239.243	145.147	
C71	6	192.200	160.160	197.207	137.167	237.243	149.161	2MM:A35;
C97	6	192.194	156.160	187.201	135.165	241.245	129.141	
C98	6	194.194	158.162	205.207	151.159	237.237	147.149	
C121	6	192.192	160.164	187.207	135.149	239.243	147.149	
C136	6	194.196	162.162	201.203	151.159	237.243	145.149	
C149	6	196.200	160.160	187.197	135.159	243.243	149.149	
C189	6	192.194	160.164	205.207	159.159	243.243	145.149	
C245	6	192.200	160.160	187.207	135.159	239.243	149.161	2MM:A8;
C248	6	194.198	158.164	205.205	135.159	241.243	147.149	

Individual	# Loci	*G1A*	*G10B*	*G10J*	*G10L*	*MU59*	*G10X*	Similar Genotypes
C271	6	192.196	160.160	187.207	149.159	239.243	147.149	
C286	6	192.196	160.162	201.201	135.159	237.239	127.147	
C287	6	194.196	162.164	199.205	151.171	237.243	147.147	
C300	6	184.196	158.162	201.207	135.159	237.239	127.145	
C305	6	190.194	158.158	187.207	159.159	237.237	145.147	

Figure A 1. Pie charts of the precent cover of site series classifications for CWHms1 and MHmm1 at each of the DNA hair snagging sites in the RMOW.



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16%
10%
1%
20%
48%
1
2
3
GP
PL
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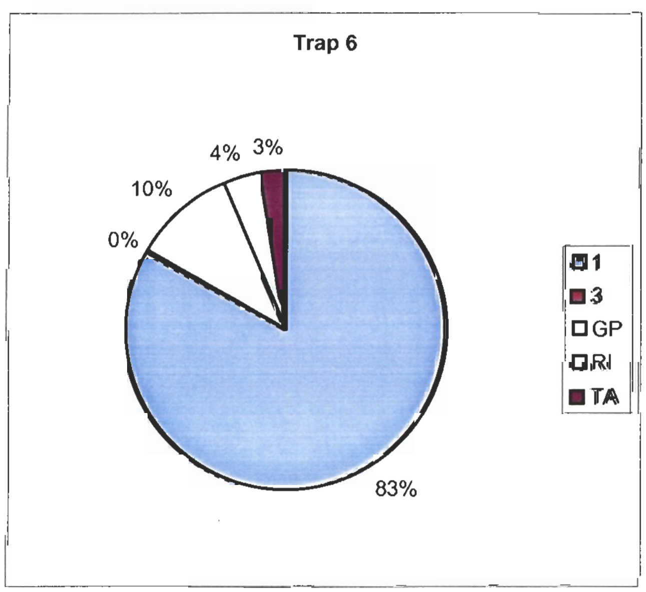
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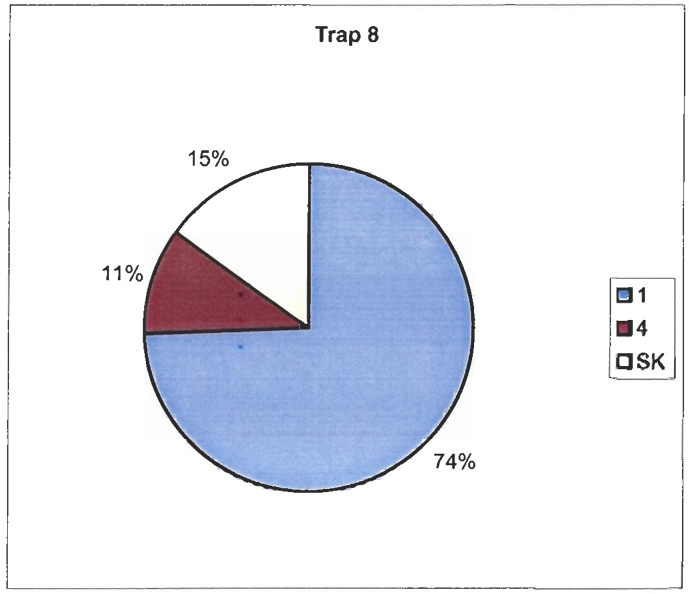
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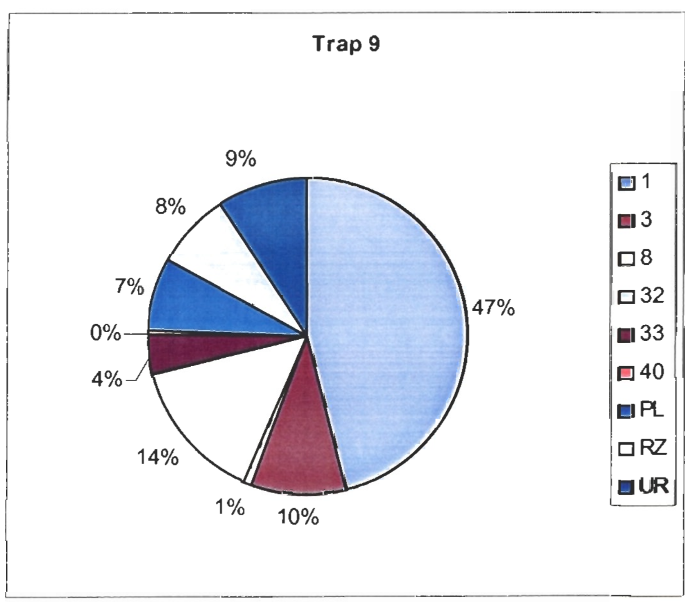
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4%
14%
1%
10%
47%
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3
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33
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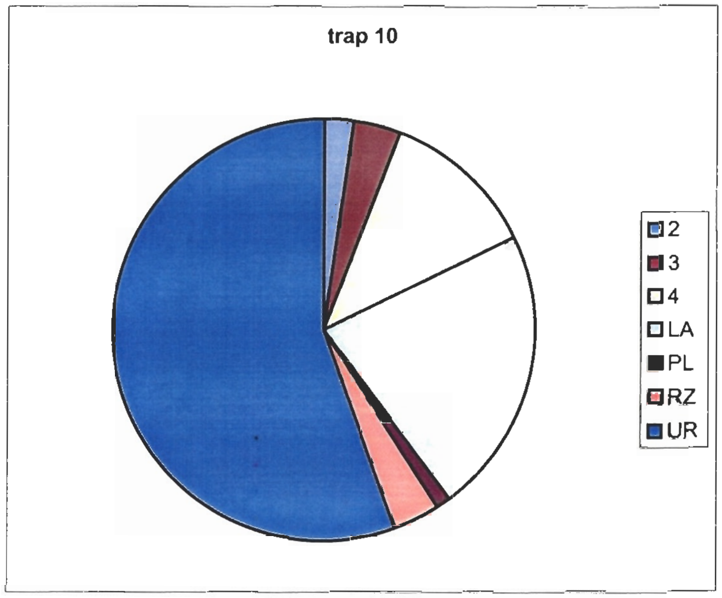
PL
RZ
UR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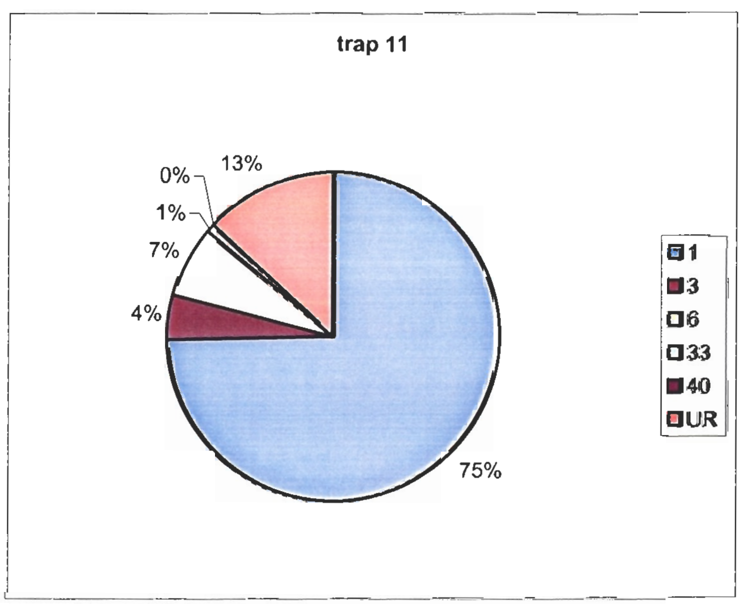
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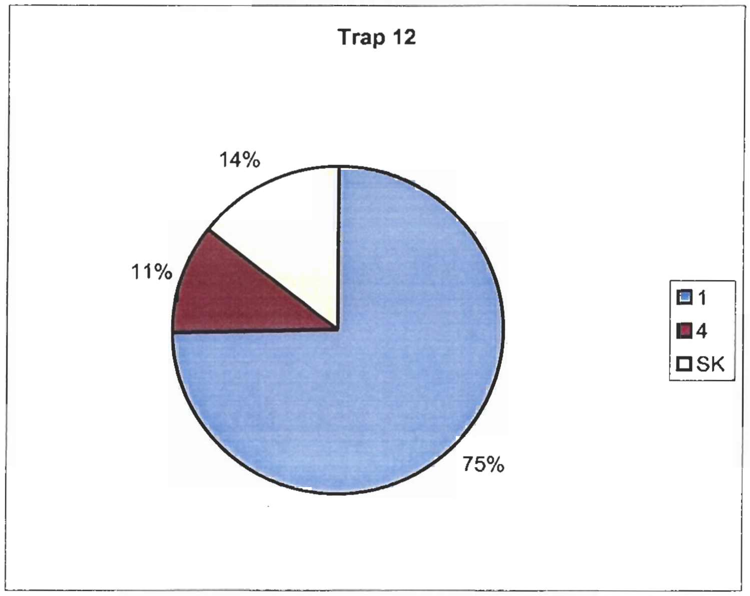
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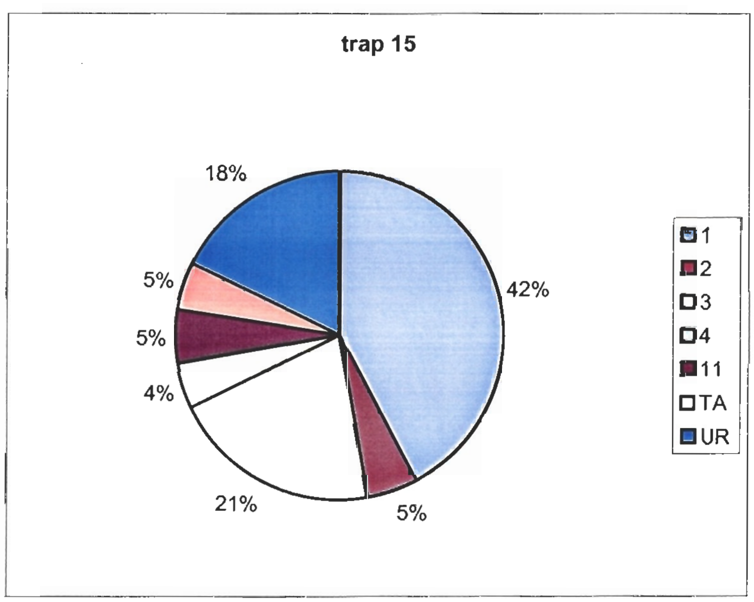
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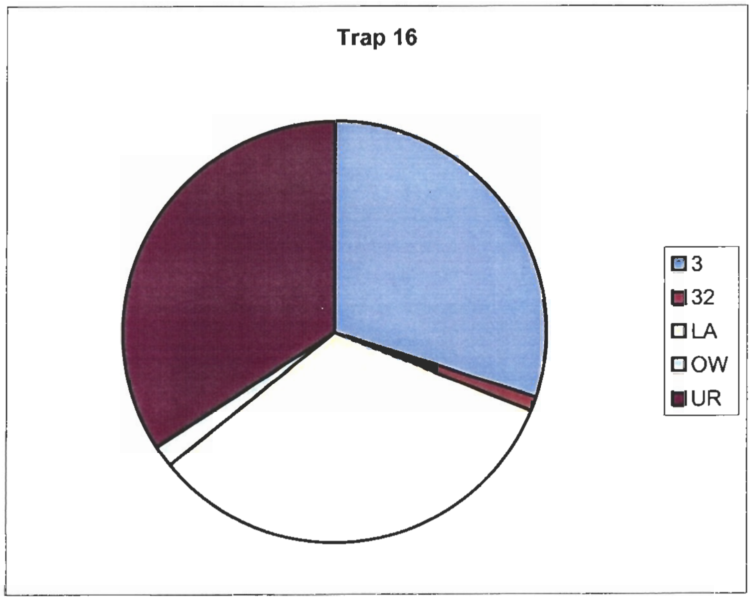
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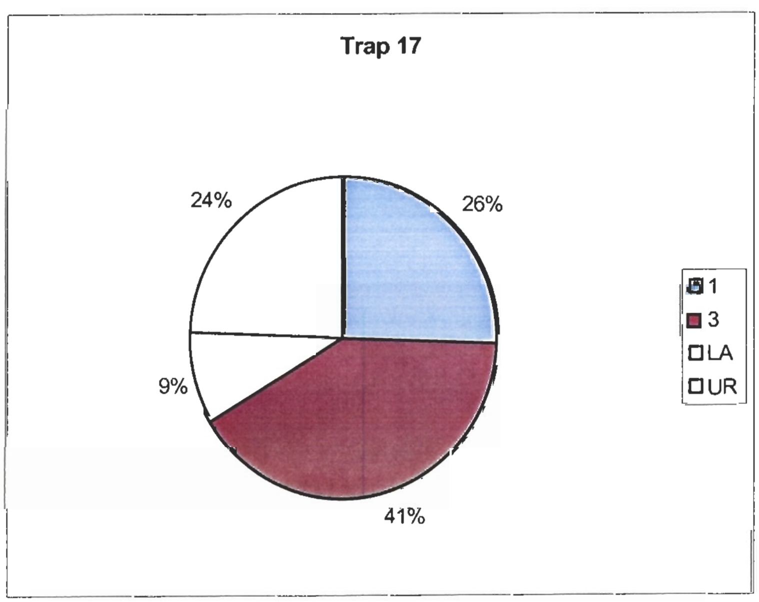
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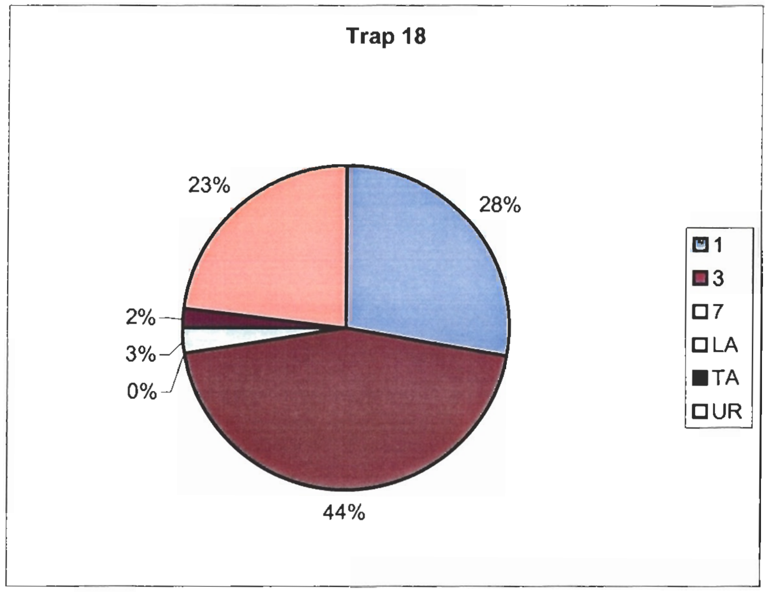
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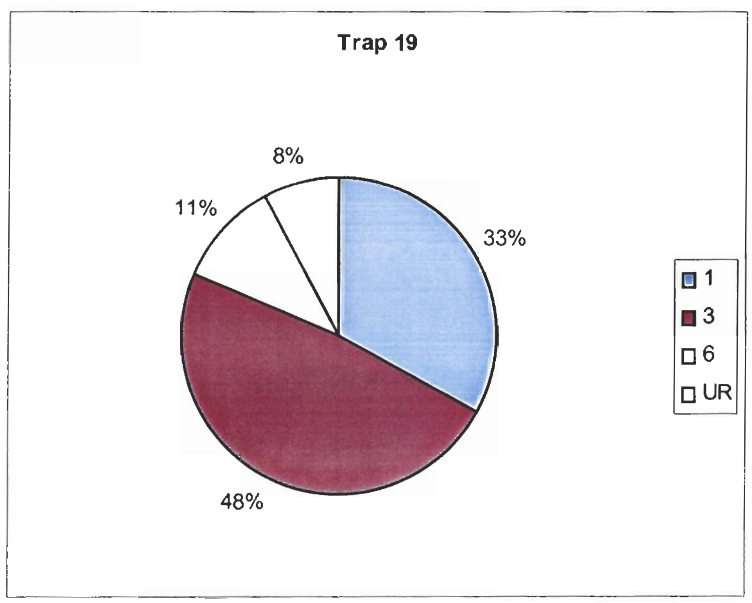
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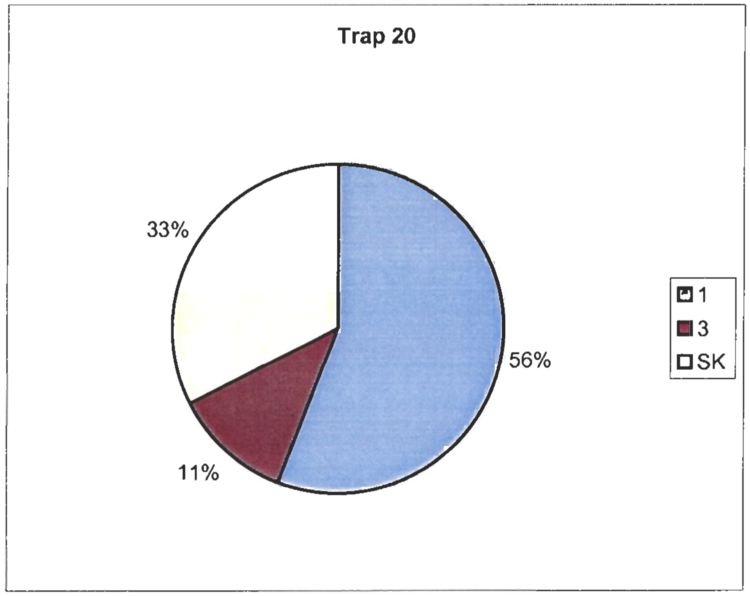
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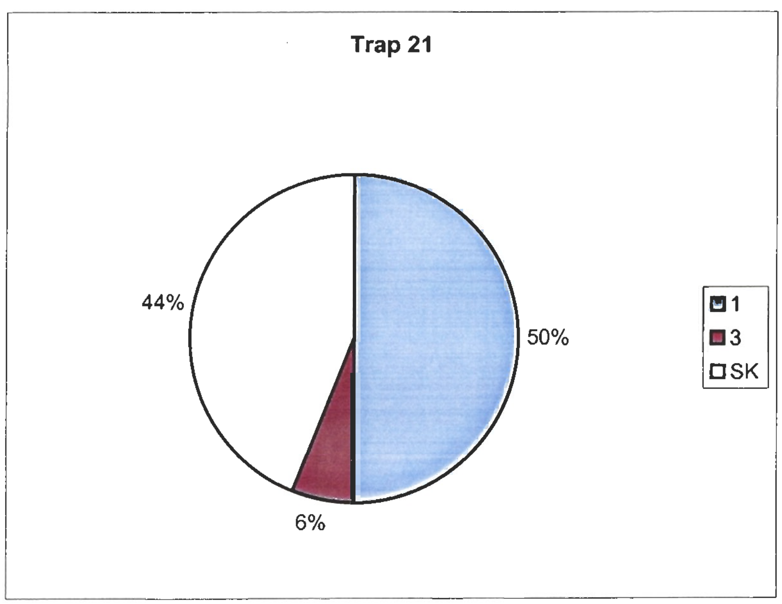
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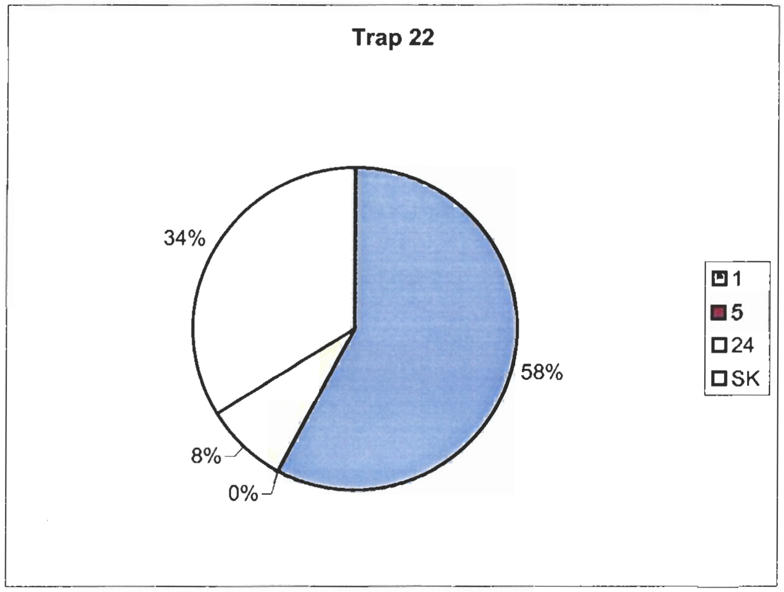
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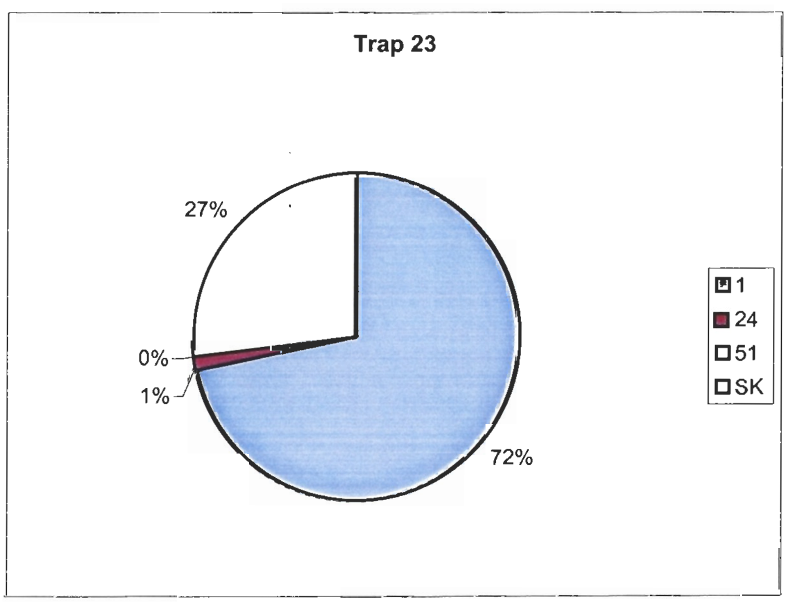
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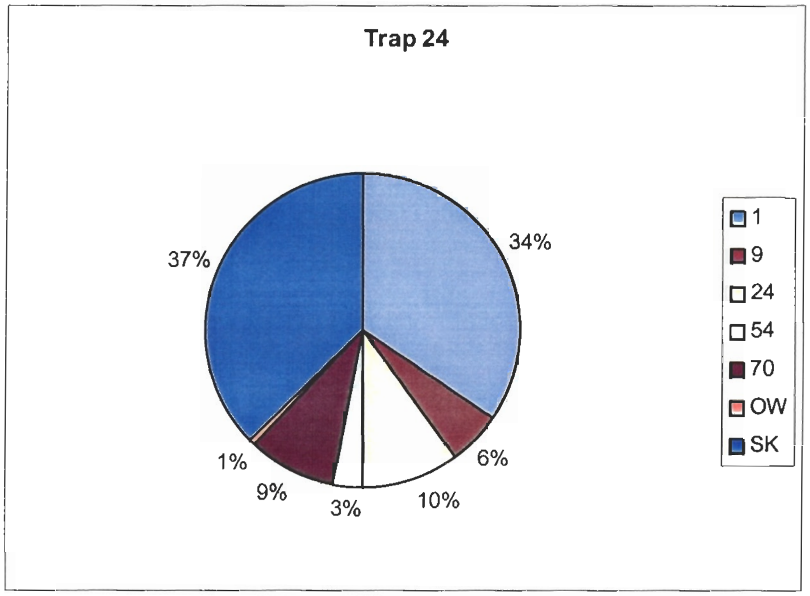
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OW
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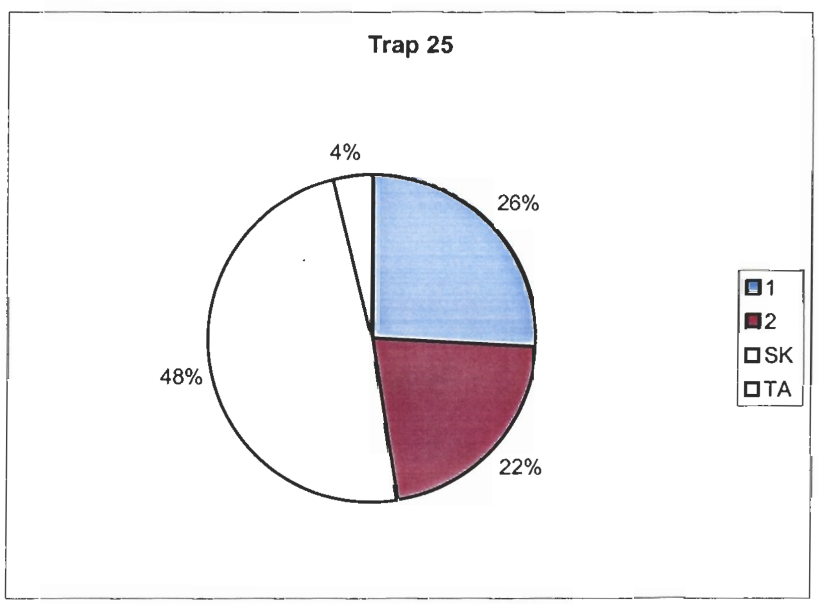
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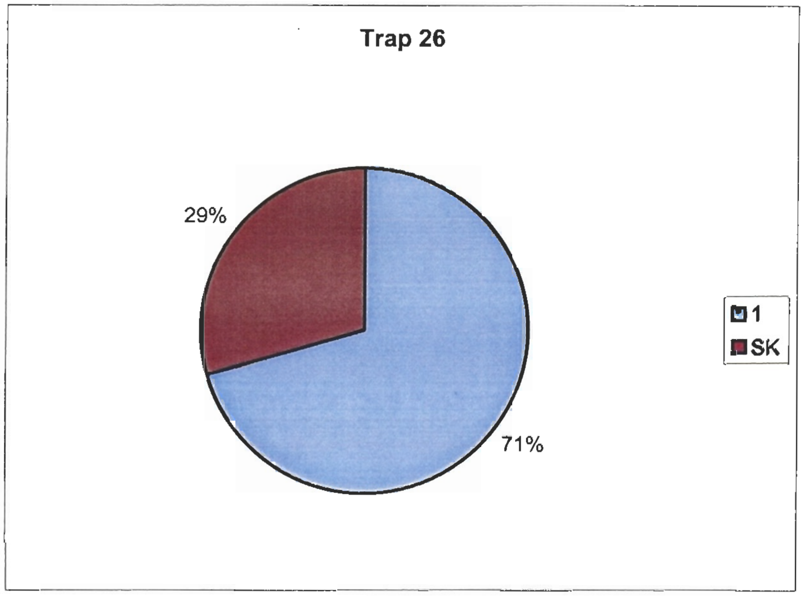
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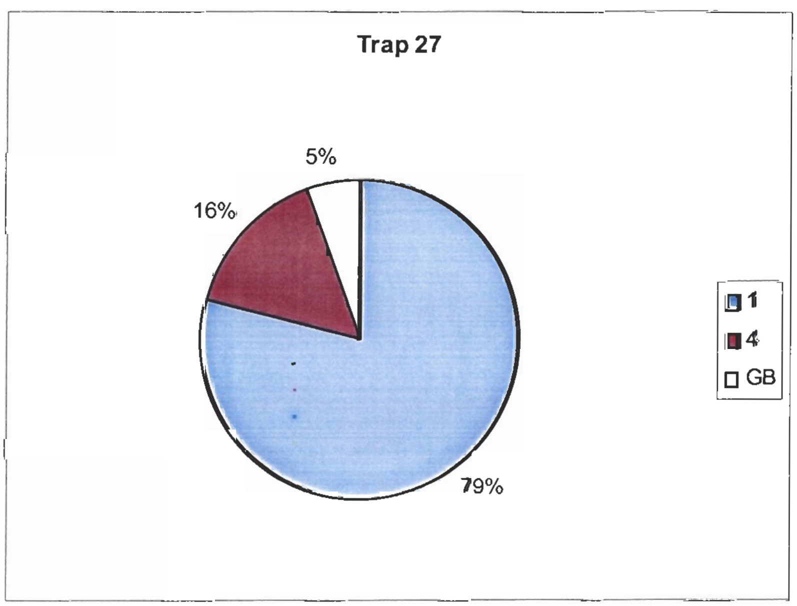
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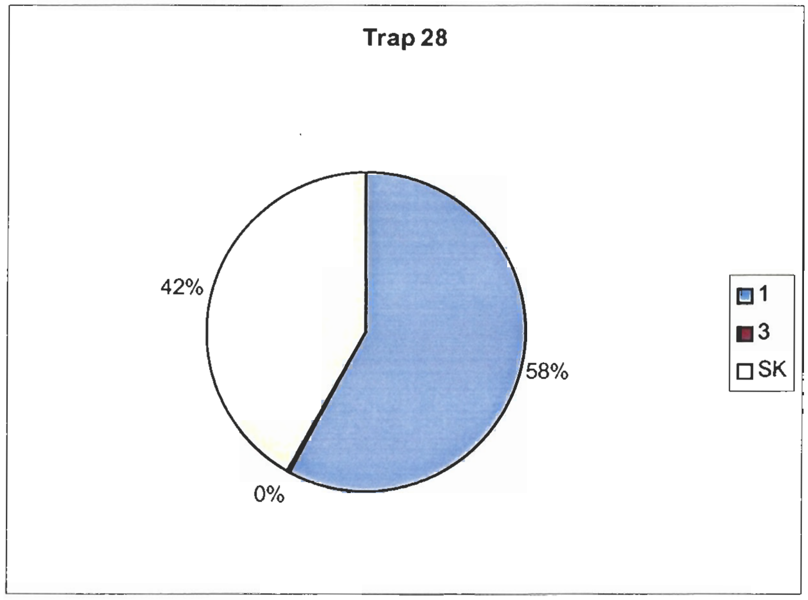
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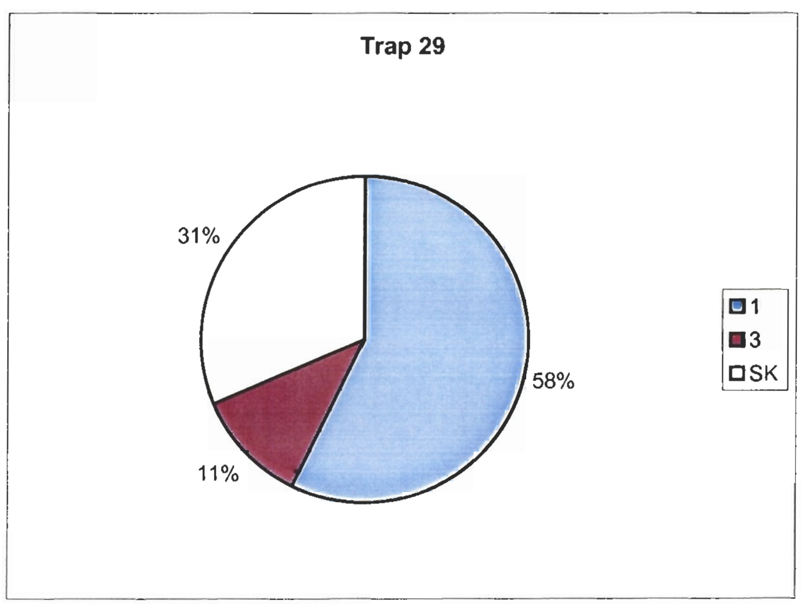
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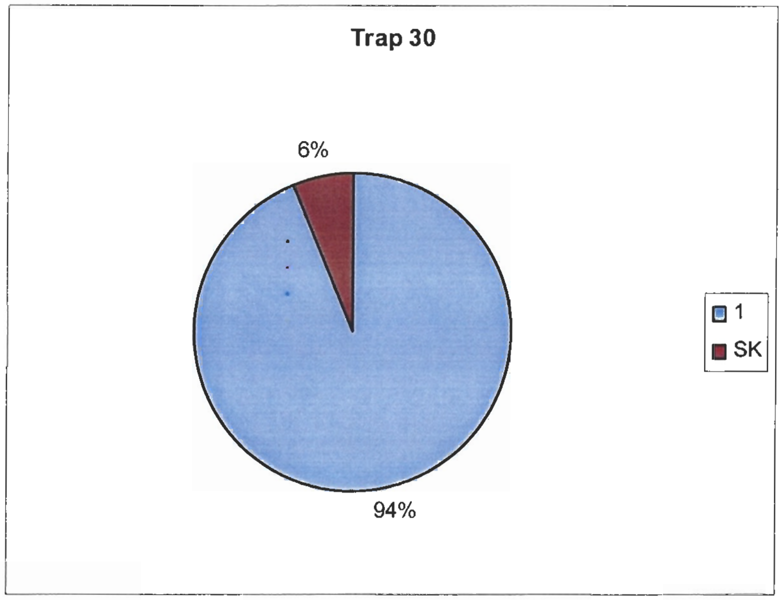
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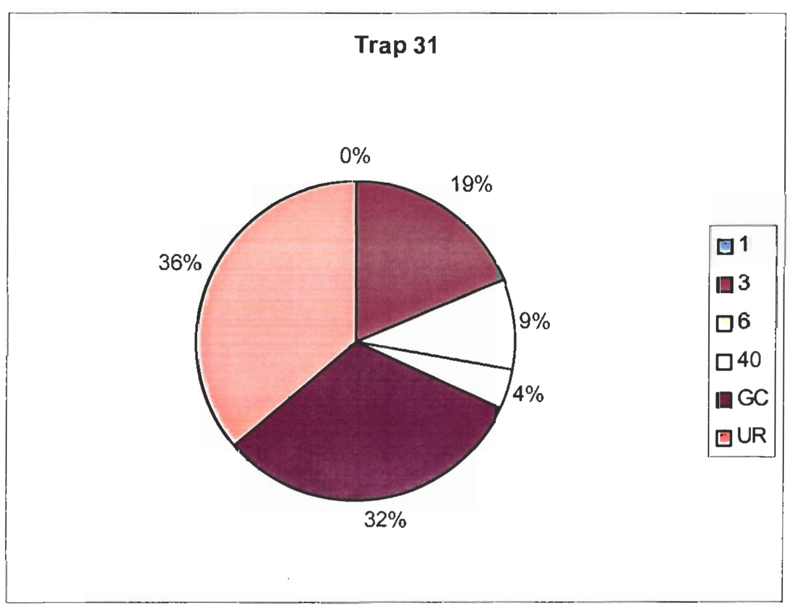
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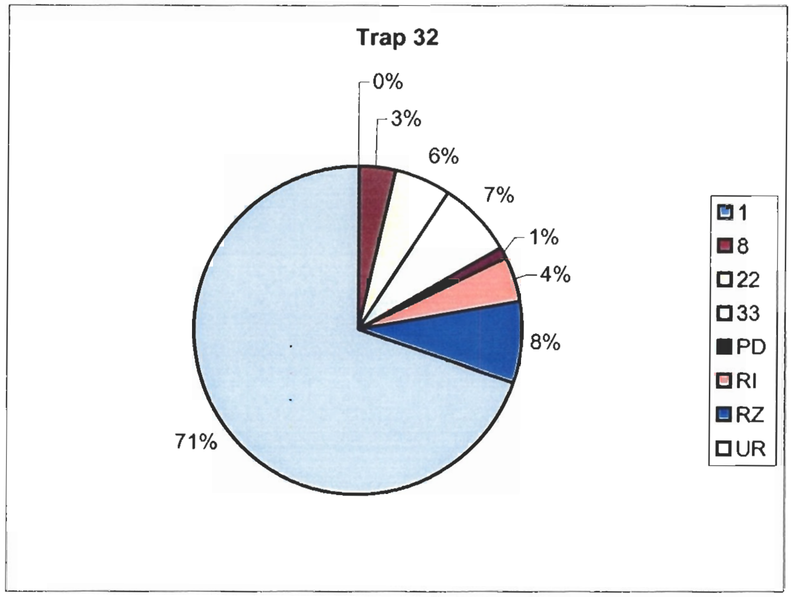
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PD
RI
RZ
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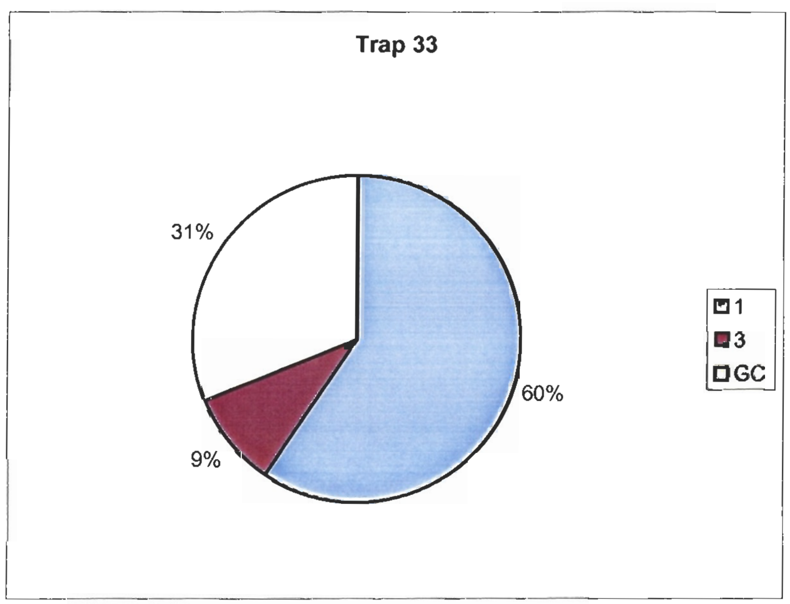
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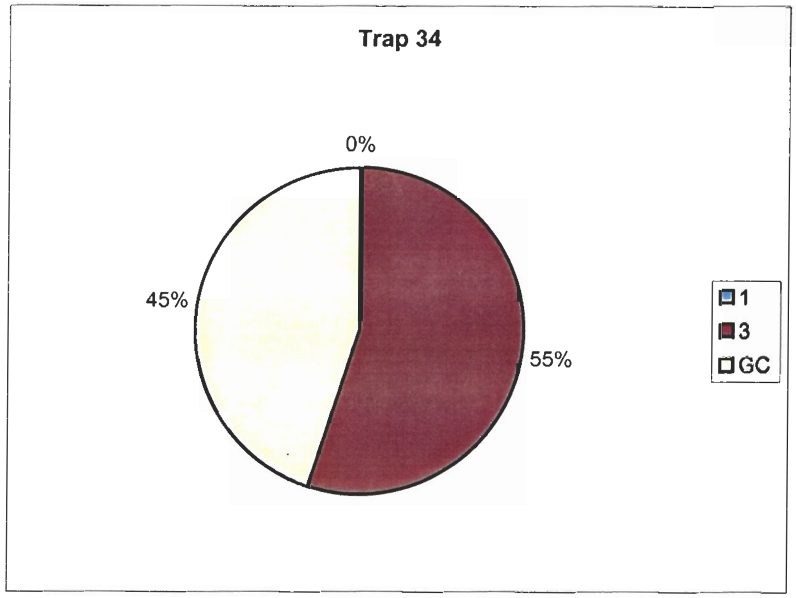
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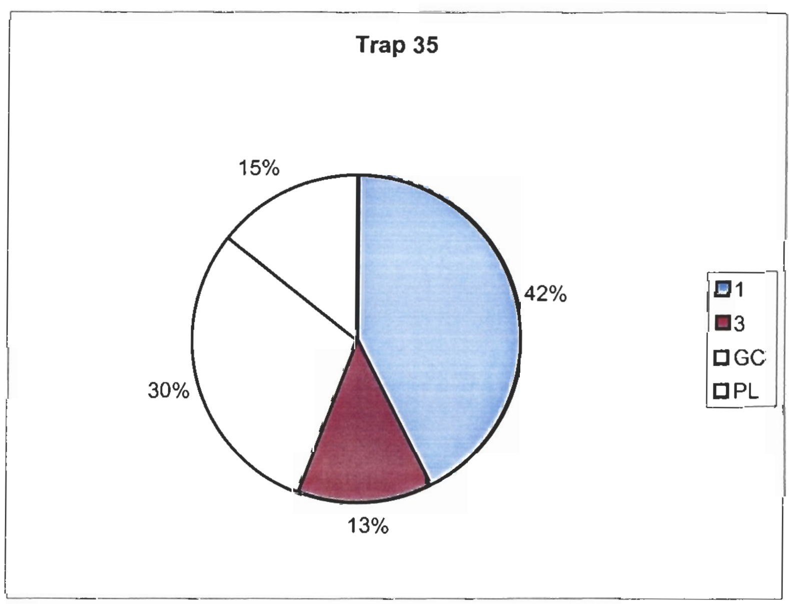
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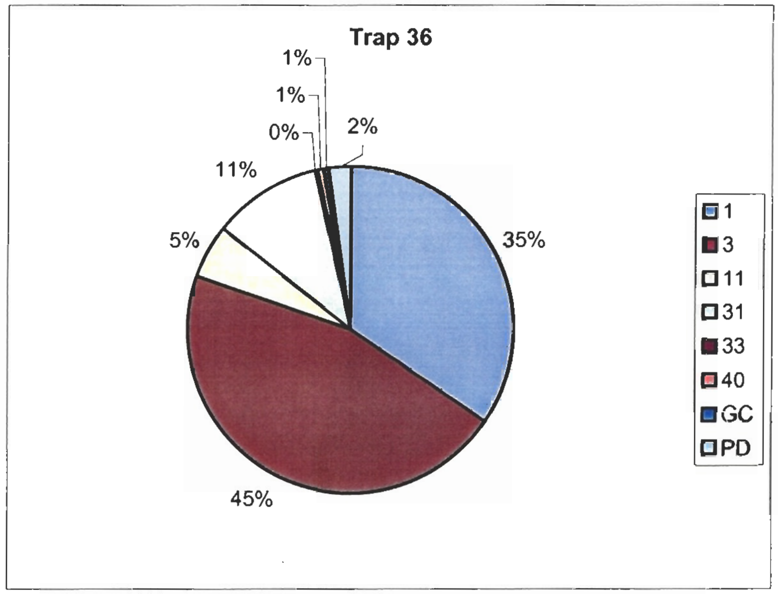
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GC
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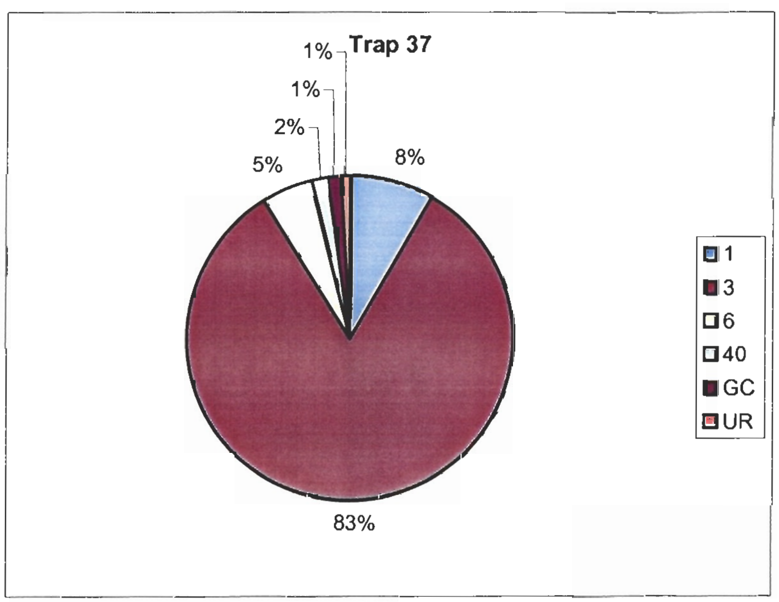
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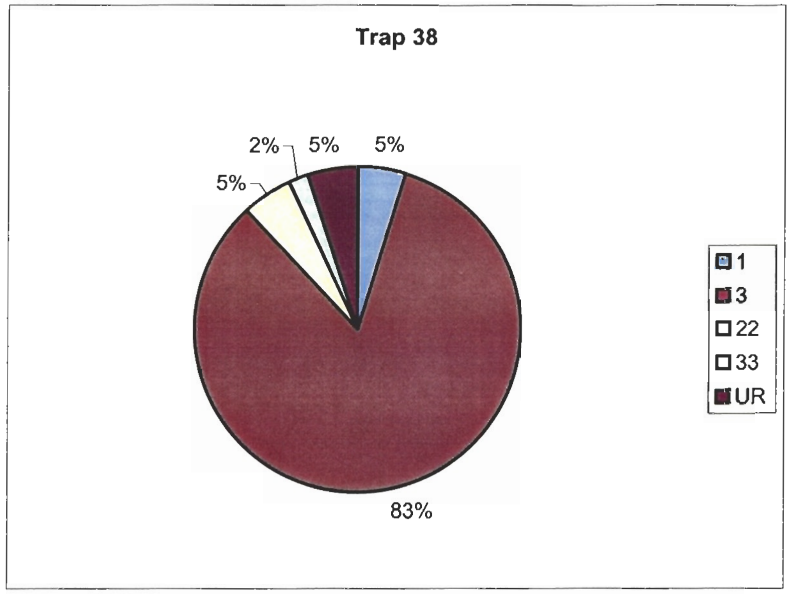
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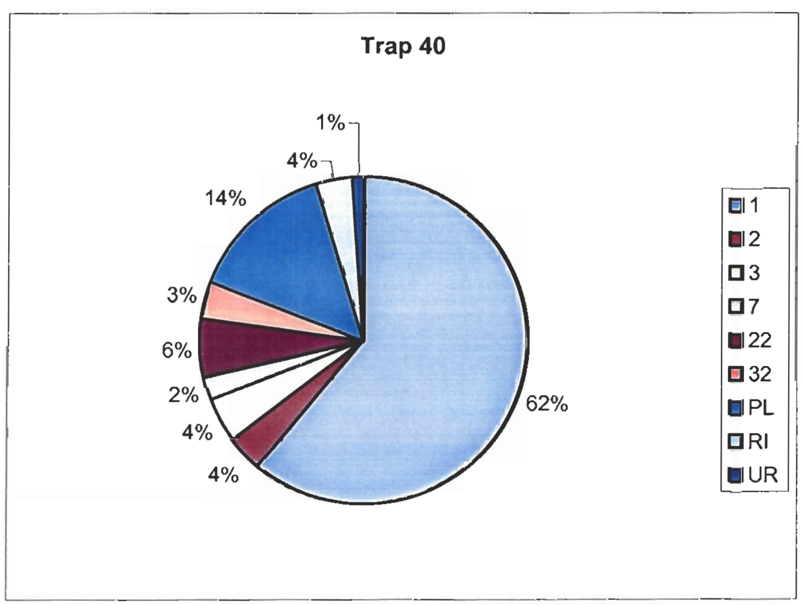
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62%
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2
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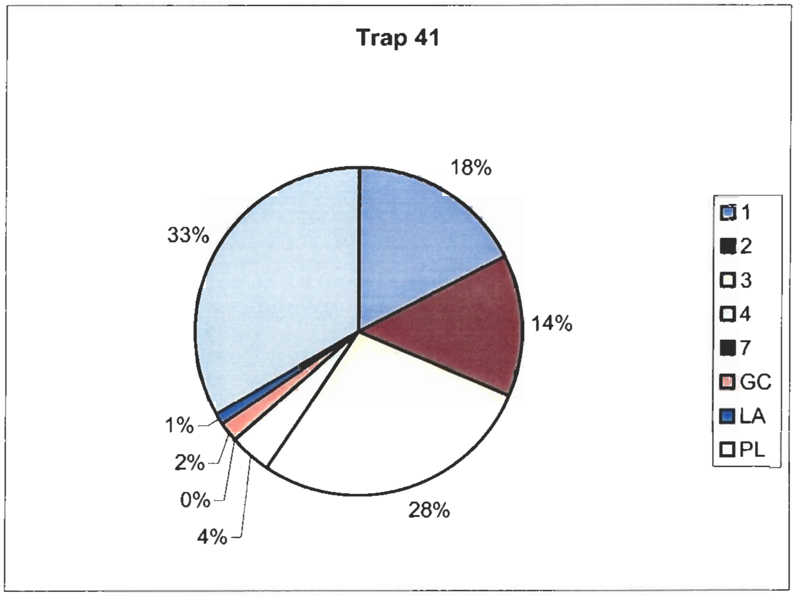
RI
UR


Trap 41
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2
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LA
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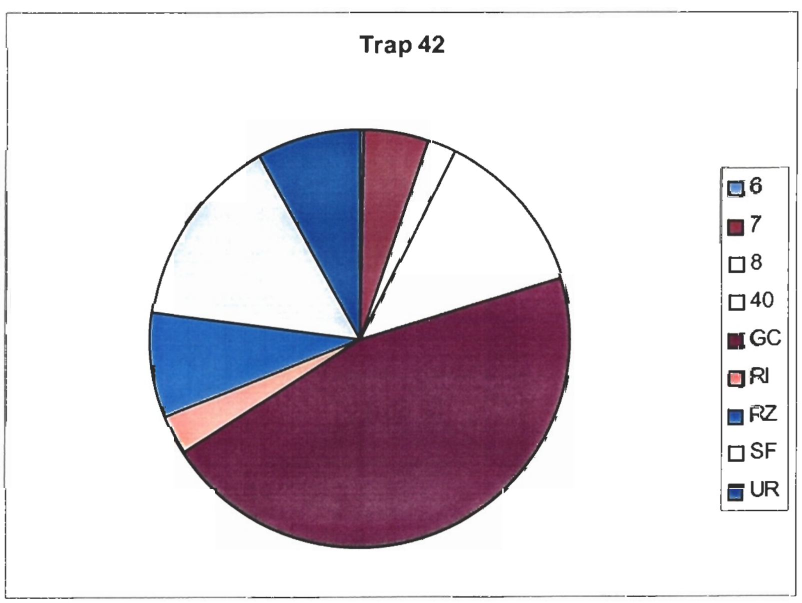
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8
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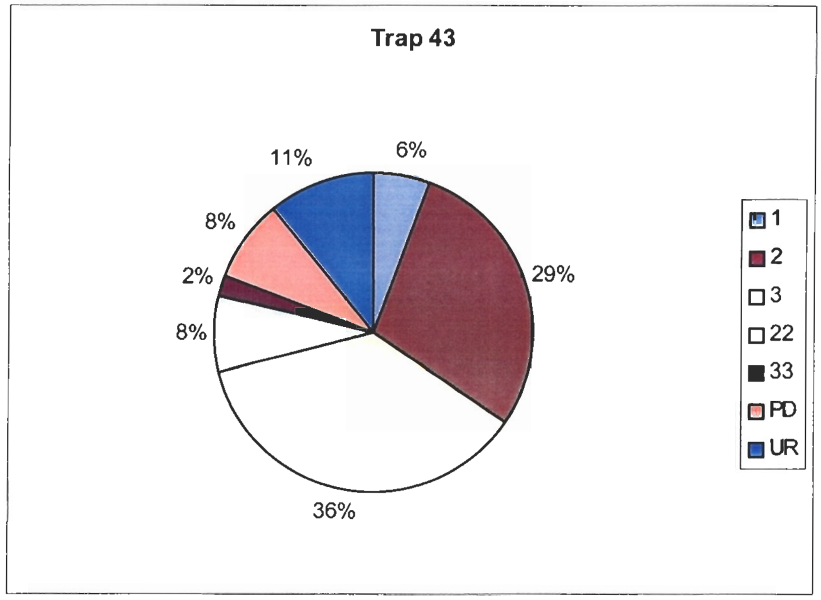
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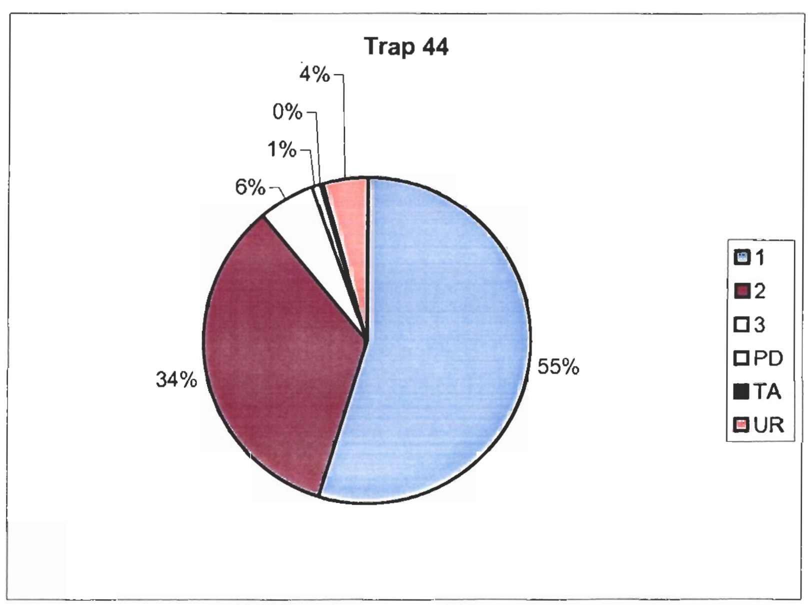
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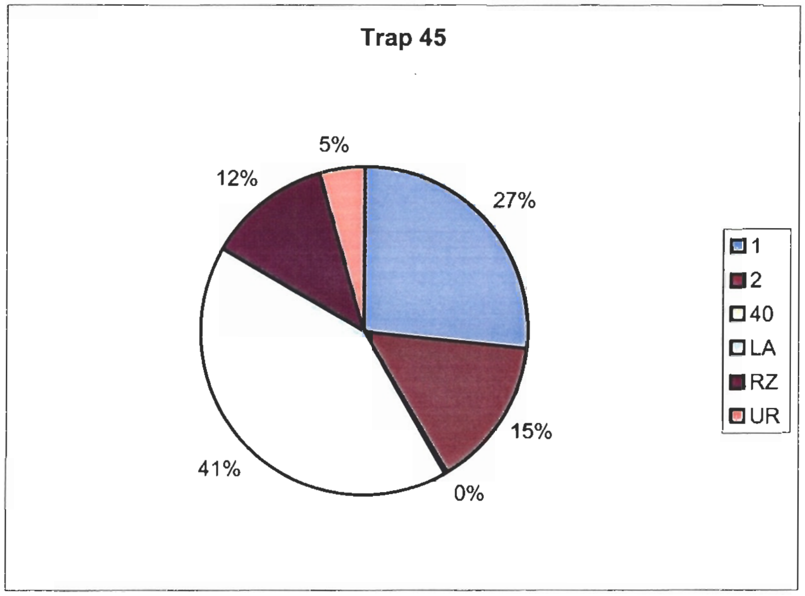
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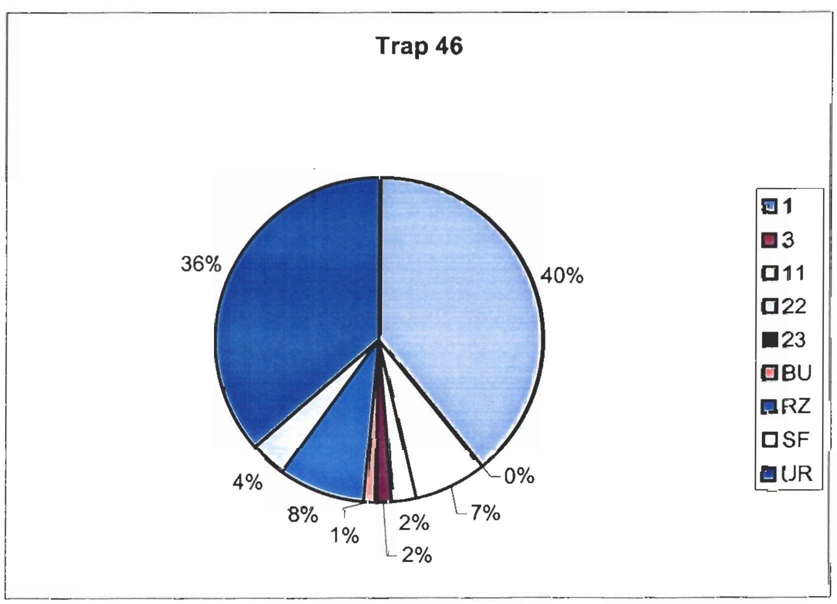
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3
11
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SF
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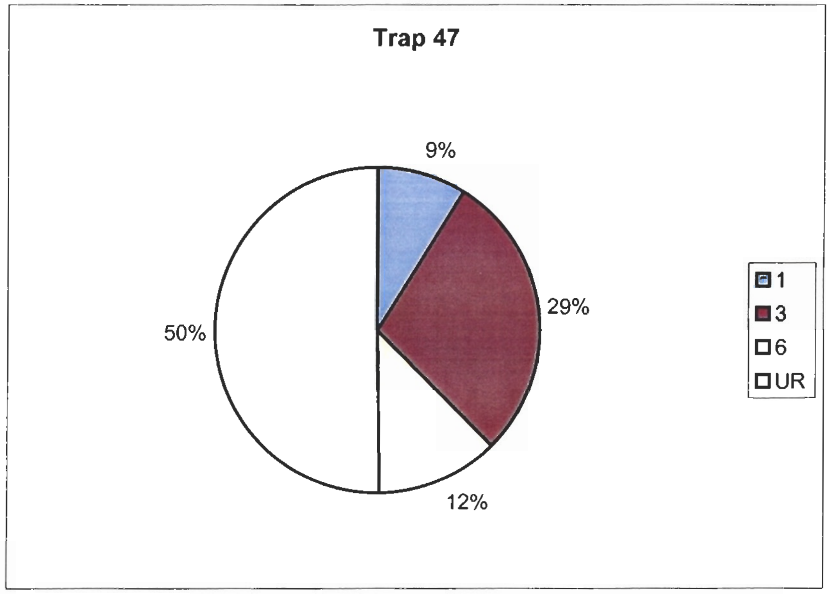
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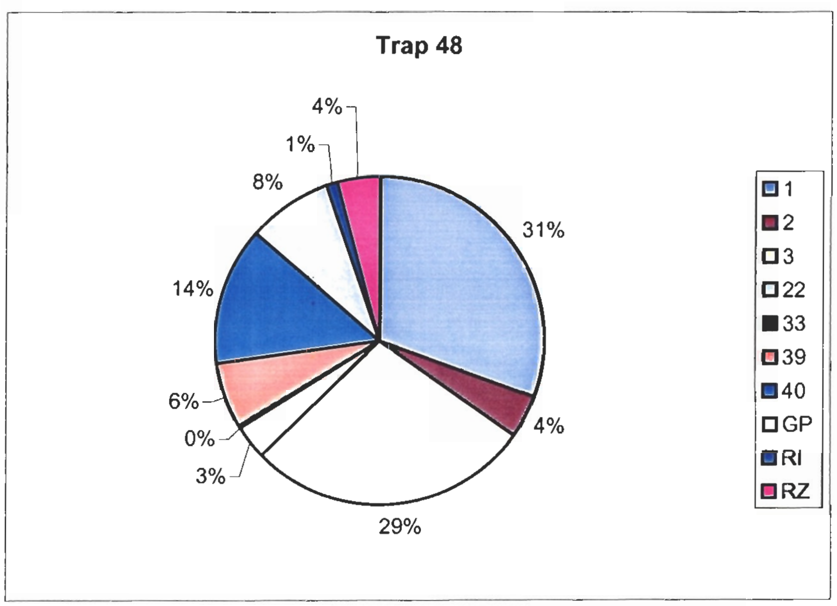
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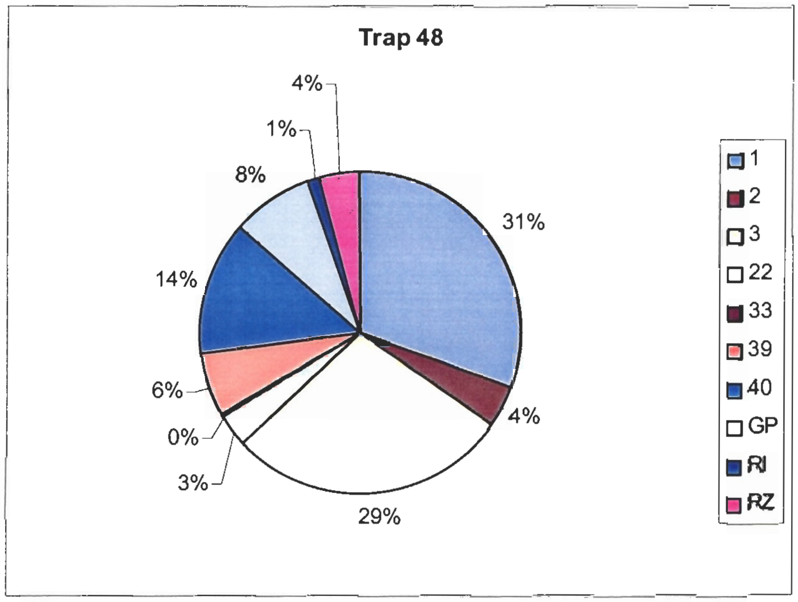
RZ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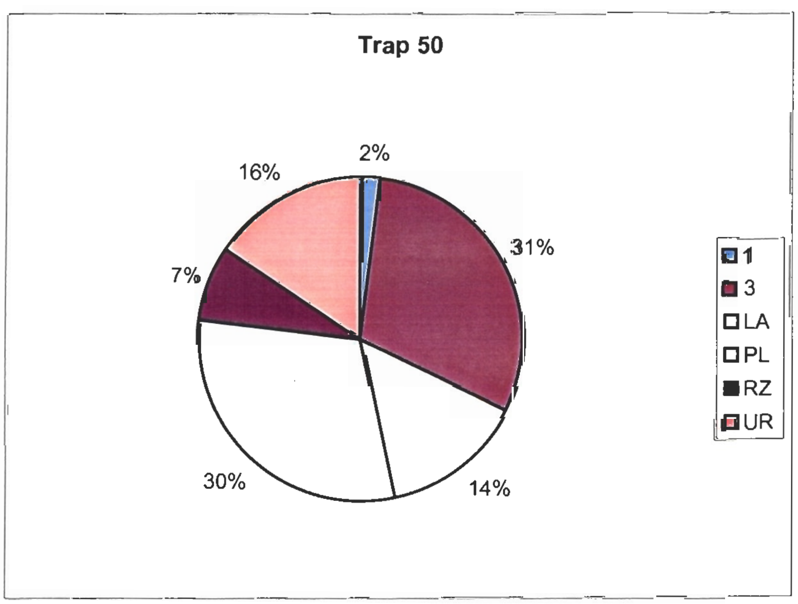
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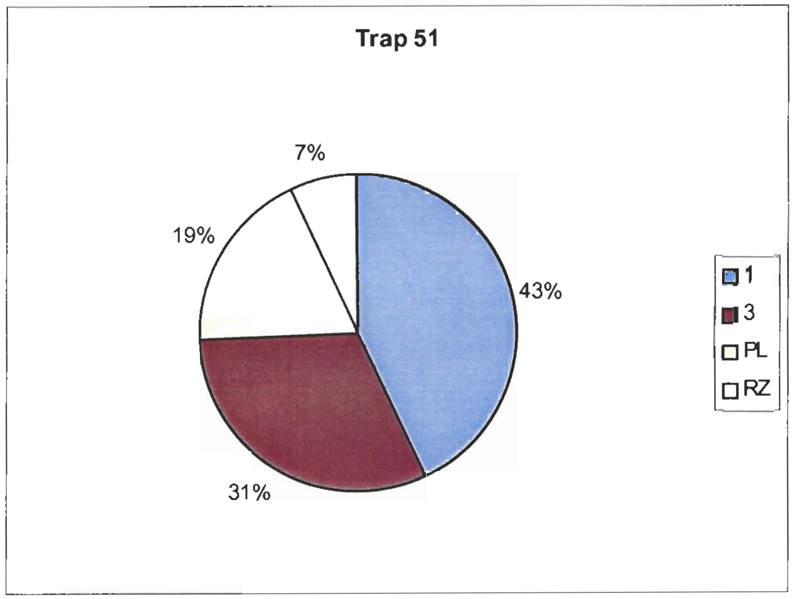
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PL
RZ