FEASIBILITY OF REINTRODUCING THE RIVER OTTER (*LONTRA CANADENSIS*) IN SOUTH DAKOTA

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

FEASIBILITY OF REINTRODUCING THE RIVER OTTER (*LONTRA CANADENSIS*) IN SOUTH DAKOTA

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Currently, river otters (*Lontra canadensis*) occupy half their historical range, which extends throughout Canada and northern parts of the United States including the Great Lakes, the northeast, and the northwest regions. The river otter is a state-threatened species in South Dakota. I determined the current status and distribution of the river otter population and whether adequate habitat was available for reintroducing river otters in South Dakota. Rivers were selected by buffering specific features, such as stream size (orders three to seven), water gradient, and water permanence, using the South Dakota Gap Analysis Project stream reach and watershed data. Vegetation transect sampling was conducted and a water sample was collected at each study site. Once information was obtained, rivers were rated (one to five, where river otter suitability increases with increased values) according to river otter habitat requirements and based on stream characteristics, watershed features, water quality, prey availability, and other factors (e.g., private or public ownership and stream accessibility). No remnant river otter population was found in South Dakota. Eighty-nine percent of river otter sightings were observed in eastern South Dakota. River otter sightings were more likely in eastern

South Dakota due to the river otter reintroduction efforts by the Flandreau Santee Sioux Tribe. Percent canopy cover of riparian vegetation ranged from 0 to 29. Percent cover of graminoid ranged from 11 to 40, forbs ranged from 16 to 40, shrubs ranged from 3 to 24, and other (e.g., litter) ranged from 0 to 26. Secchi depth ranged from 0.01 m to 0.9 m, dissolved oxygen ranged from 5 ppm to 11.0 ppm, alkalinity (methyl-orange) ranged from 140 mg/l to 740 mg/l, and pH ranged from 7.5 to 8.5. Phosphorus (orthophosphate) ranged from 0.7 mg/l to 6.3 mg/l, nitrogen (nitrate-nitrogen) ranged from 0.01 mg/l to 0.26 mg/l, and temperature ranged from 18 C to 29 C. Important prey species include fish, especially species within the Ictaluridae (catfish and bullheads) and Catostomidae (suckers) families. Rivers with high ratings had better habitat, higher water quality, and greater prey availability than rivers with low ratings. The five highest rated river systems in South Dakota were the Bad River (75), Big Sioux River (74), James River (72), North Fork of the Whetstone River (72), and Little White River (69). After establishing that areas with adequate river otter habitat were available in South Dakota, a river otter reintroduction protocol was developed. The protocol included river otter release procedures, estimation of reintroduction expenses, and consideration of logistical problems.

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INTRODUCTION

Ecology

The river otter (*Lontra canadensis*), a member of the family Mustelidae, is an important furbearer, weighing from 6.8 to 11.3 kg. Females are smaller than males (Toweill and Tabor, 1982). Because river otters are semi-aquatic mammals, they have features adapted to their lifestyle (Jones et al., 1983; Reid et al., 1988; Higgins et al., 2000). The river otter's waterproof and thick, dense fur is dark-brown above and silvery below, giving them proper camouflage and protection from environmental elements in winter and summer (Burt and Grossenheider, 1980; Jones et al., 1983; Lariviere and Walton, 1998; Higgins et al., 2000). Eyes of the river otter are located on the dorsal surface of the head allowing them to scan the water's surface while swimming. Ears of the river otter are small and placed to hear above water as they swim. The river otter's large, webbed feet are used for swimming, while their long, sensitive vibrissae are used to maneuver through turbid waters and locate prey (Toweill and Tabor, 1982).

River otters exhibit delayed implantation, which involves discontinuous development of the embryo (Andelt, 1992). Females give birth 12 months after conception; the 12-month cycle includes a ten-month inactive period and a two-month gestation period (Melquist and Hornocker, 1983; Lariviere and Walton, 1998; Higgins et al., 2000). Females breed for the first time at two years of age, but become pregnant at three years of age (Melquist and Hornocker, 1983; Lariviere and Walton, 1998). Males reach sexual maturity at two years of age, but are not successful breeders until five to seven years of age (Toweill and Tabor, 1982). Mating occurs in March or April in most

temperate areas with young typically born in late April the following year (Toweill and Tabor, 1982; Jones et al., 1983; Andelt, 1992; Lariviere and Walton, 1998).

Litter size of river otters ranges from one to six pups (mean = 2.5). When the litter of altricial pups is born, parental care is provided by the mother (Jones et al., 1983; Andelt, 1992; Lizotte and Kennedy, 1997; Higgins et al., 2000). The mother and her young comprise the social group (Griess, 1987; Johnson and Madej, 1994; Schlarbaum, 1996). At three weeks, the young open their eyes and begin to develop important social skills. At five months, the pups are weaned and two months later they disassociate from their mothers (Jones et al., 1983; Melquist and Hornocker, 1983).

Typically, river otters feed in shallow rivers (1.0 to 1.5 m) and hunt in pairs, small groups, or alone (Beckel, 1990). River otters catch the most plentiful and sluggish prey available, including fish (Toweill, 1974; Lizotte and Kennedy, 1997). Toweill and Tabor (1982) noted that river otters select fish in direct proportion to their availability and in inverse proportion to their swimming ability. In winter and summer, fish are consumed in higher frequencies than in spring or fall (Serfass et al., 1990). Greer (1955) stated that fish selection by river otters in northwestern Montana varied by seasons; Centrarchidae (sunfish) were selected during summer and Catostomidae (suckers) were selected during winter. In Massachusetts, Loranger (1981) discovered that the most common fish prey during late fall and winter were Ictaluridae (catfish and bullheads) and Centrarchidae. In western Oregon, river otters consumed Salmonidae (salmon and trout) and Cottidae (sculpins) frequently and Ictaluridae and Centrarchidae infrequently based on availability

(Toweill, 1974). In addition, Cyprinidae (minnows) and Percidae (perch) may contribute to the diet of the river otter (Toweill and Tabor, 1982).

Supplemental prey species include muskrats (*Ondatra zibethicus*), frogs and bullfrogs (*Rana* spp.), mudpuppies (*Necturus maculosus*), salamanders (*Ambystoma* spp.), crayfish (*Cambarus* spp. and *Procambarus* spp.), and mussels (Class Bivalvia) (Greer, 1955; Loranger, 1981; Serfass et al., 1990; Lizotte and Kennedy, 1997). River otters select crayfish, amphibians, and other aquatic invertebrates more often in summer due to the greater abundance and accessibility of these organisms; these are important food items (Knudsen and Hale, 1968; Serfass et al., 1990; Lizotte and Kenney, 1997). River otters are efficient and opportunistic predators, selecting their prey based on abundance and completely utilizing the catch (Greer, 1955; Toweill, 1974; Loranger, 1981; Lizotte and Kennedy, 1997).

River otters utilize lakes, streams, rivers, meadow grasslands, and wetlands (Melquist and Hornocker, 1983; Lizotte and Kennedy, 1997; Luce et al., 1997). A constant water supply and slightly fluctuating water levels are important aspects of habitat because river otters have large home ranges and need ample water levels for movement.

River otters move extensively during some seasons, and travel routes characteristically follow waterways (Johnson and Madej, 1994; Lariviere and Walton, 1998). Melquist and Hornocker (1983) found considerable variation in movements between individual river otters. Typically, river otter movements are greater in spring and summer than in winter and fall, perhaps due to food availability (Lariviere and

Walton, 1998). Seasonal fluctuations in river otter habitat use are associated with suitable den/resting sites, food availability, and distribution of open water in winter (Anderson and Woolf, 1987). During the breeding season, males show increased movements and females display decreased movements. Females increase their movements once young have dispersed (Melquist and Hornocker, 1983).

Home range of river otters varies with sex, age, reproductive status, season, prey availability, habitat conditions, drainage patterns, and distribution of other river otters (Johnson and Madej, 1994). Males inhabit a larger home range than females (Lariviere and Walton, 1998); the average male home range is 20 to 30 km of stream length, while the average female home range is 15 km (Toweill and Tabor, 1982). Territoriality does not occur and intra- and intersexual home ranges overlap (Johnson and Madej, 1994; Lariviere and Walton, 1998). Males occupy a home range to secure breeding areas, whereas females occupy a home range to secure feeding areas (Toweill and Tabor, 1982). In a riverine system, river otters have a linear home range, while river otters that primarily use wetlands have a polygonal home range (Johnson and Madej, 1994). Throughout the year, a river otter can occupy nearly 80.5 km of a riverine system, but they usually reside within a few kilometers of the stream (Andelt, 1992). Such areas are considered activity centers, which provide an abundance of food, adequate shelter, and minimal human disturbance (Griess, 1987).

River otter populations are positively correlated with the presence of beavers (*Castor canadensis*) and shoreline diversity, in features such as bank slope and vegetation (Dubuc et al., 1990; Dronkert-Egnew, 1991; Lariviere and Walton, 1998). Where

beavers are present, the habitat is generally suitable for river otters (Dubuc et al., 1990; Lariviere and Walton, 1998). Shoreline diversity is valuable for river otter habitat because it promotes adequate feeding areas (Dubuc et al., 1990; Dronkert-Egnew, 1991).

River otters live in underground dens most of the year but rarely build their own (Andelt, 1992). River otters seek dens in a natural shelter or dens made by another animal, such as abandoned beaver lodges or bank dens (Luce et al., 1997). Dronkert-Egnew (1991) noted that river otters in northwestern Montana selected areas with waterway obstructions, such as emergent vegetation and logs or logjams, and avoided areas with low understory cover and higher disturbance, such as bridges and roads.

The curious and playful social behavior of river otters is well documented (Anderson and Woolf, 1987; Schlarbaum, 1996; Ben-David et al., 1998; Hamilton, 1999). River otters socialize by sliding, wrestling, throwing rocks or clams, and playing with their captured prey (Andelt, 1992). The social group consists of an adult female and her juvenile offspring, but assorted group associations are common (Johnson and Madej, 1994; Lariviere and Walton, 1998). Aggression rarely occurs; conflicts are solved by mutual avoidance (Melquist and Hornocker, 1983). River otters communicate through smell, sound, and tangible signals (Melquist and Hornocker, 1983). Scent marking with feces, urine, and anal secretions are essential elements of inter-group communication (Melquist and Hornocker, 1983).

Historical and Current Status

Historically, the river otter occupied all major waterways of the United States and Canada (Halbrook, 1978; Hall, 1981; Jones et al., 1983; Lariviere and Walton, 1998). River otters once occupied one of the largest geographic ranges of any North American mammal, along with the beaver, gray wolf (*Canis lupus*), and mountain lion (*Puma concolor*) (Toweill and Tabor, 1982). At present, the river otter is abundant in Alaska, most of Canada, the Pacific Northwest, the Great Lakes region, and most states along the Atlantic Coast and Gulf of Mexico (Andelt, 1992). In other states, particularly the Midwest, river otter populations are not faring as well (Halbrook, 1978; Choromanski and Fritzell, 1982; Toweill and Tabor, 1982). Presently, river otters occupy less than 33% of their historical range in the contiguous 48 states. River otters are protected in 17 states either as a threatened or endangered species (Melquist and Hornocker, 1983).

River otters were important furbearers for European trappers and were extirpated from South Dakota's waters due to extensive trapping, loss of habitat, and other human intervention (Over and Churchill, 1941; Choromanski and Fritzell, 1982; Toweill and Tabor, 1982; Jones et al., 1983; Melquist and Hornocker, 1983; Dronkert-Egnew, 1991; Lizotte and Kennedy, 1997; Lariviere and Walton, 1998). D. R. Frazer observed river otters at Fort Dakota (now Sioux Falls) during 1868-1869 (Ottoson, unpublished manuscript, no date). According to Grinnell (1875), the river otter survived in major waterway systems in the Black Hills. Hoffman (1877) encountered occasional river otter skins from west of the Grand River Agency. More recently, Over and Churchill (1941) stated that river otters were never common but inhabited rivers and lakes in eastern South

Dakota before the presence of trappers. Choate and Jones (1981) and Jones et al. (1985) stated that river otters were found along riparian areas and in permanent bodies of water in plains states until the late 1800's. Since 1941, biologists, landowners, and conservation officers have documented occasional sightings of river otters throughout South Dakota. These sightings may be due to river otters dispersing from established populations or from restoration programs in surrounding states, which makes it unclear whether a remnant population of river otters still exists in South Dakota. At present, the river otter is listed as a threatened species in South Dakota (Ashton and Dowd, 1991).

Current Research and Restoration Programs

Natural resource agencies in several states have initiated restoration programs in an effort to restore self-propagating populations of river otters in the central region of the United States. States involved in river otter reintroduction efforts include Arizona, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Minnesota, Missouri, Nebraska, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Utah, Virginia, and West Virginia (Beck, 1992; Raesly, 2001).

There is increased interest in restoring river otters to their native range in South Dakota. My project was initiated to determine the feasibility of reintroducing river otters in South Dakota. The objectives of this study were: 1) to determine if a remnant population of river otters exists in South Dakota, 2) to determine the likelihood of a successful river otter reintroduction program in South Dakota based on habitat and water

quality data, and 3) to develop proper river otter reintroduction protocol identifying any logistical problems likely to be encountered during the reintroduction process.

Study Area

South Dakota lies in the Northern Great Plains region and is dissected by many rivers, streams, and creeks. Natural ecosystems in South Dakota include northern floodplain forest, tall-grass prairie, mixed-grass prairie, short-grass prairie, and ponderosa pine (*Pinus ponderosa*) woodland (Figure 1). Northern floodplain forests are riparian communities that consist of cottonwood (*Populus deltoides)*, willows (*Salix* spp.), elms (*Ulmus* spp.), green ash (*Fraxinus pennsylvanica*), and boxelder (*Acer negundo*), which are accompanied by undergrowth vegetation. Tall-grass prairies consist of tall grasses, such as big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), and Indiangrass (*Sorghastrum nutans*). Mixed-grass prairies occupy the region between the tall-grass prairie and the short-grass prairie, and they include tall grasses, short grasses (e.g., blue grama [*Bouteloua gracilis*]), and intermediate grasses (e.g., little bluestem [*Schizachyrium scoparium*] and sideoats grama [*Bouteloua curtipendula*]). Short-grass prairies are in the arid west and dominated by species such as buffalograss (B*uchloe dactyloides*), blue grama, needle and thread (*Stipa comata*), and western wheatgrass (*Agropyron smithii*). Ponderosa pine trees dominate the ponderosa pine woodlands, and undergrowth vegetation is highly variable (Jones et al., 1985).

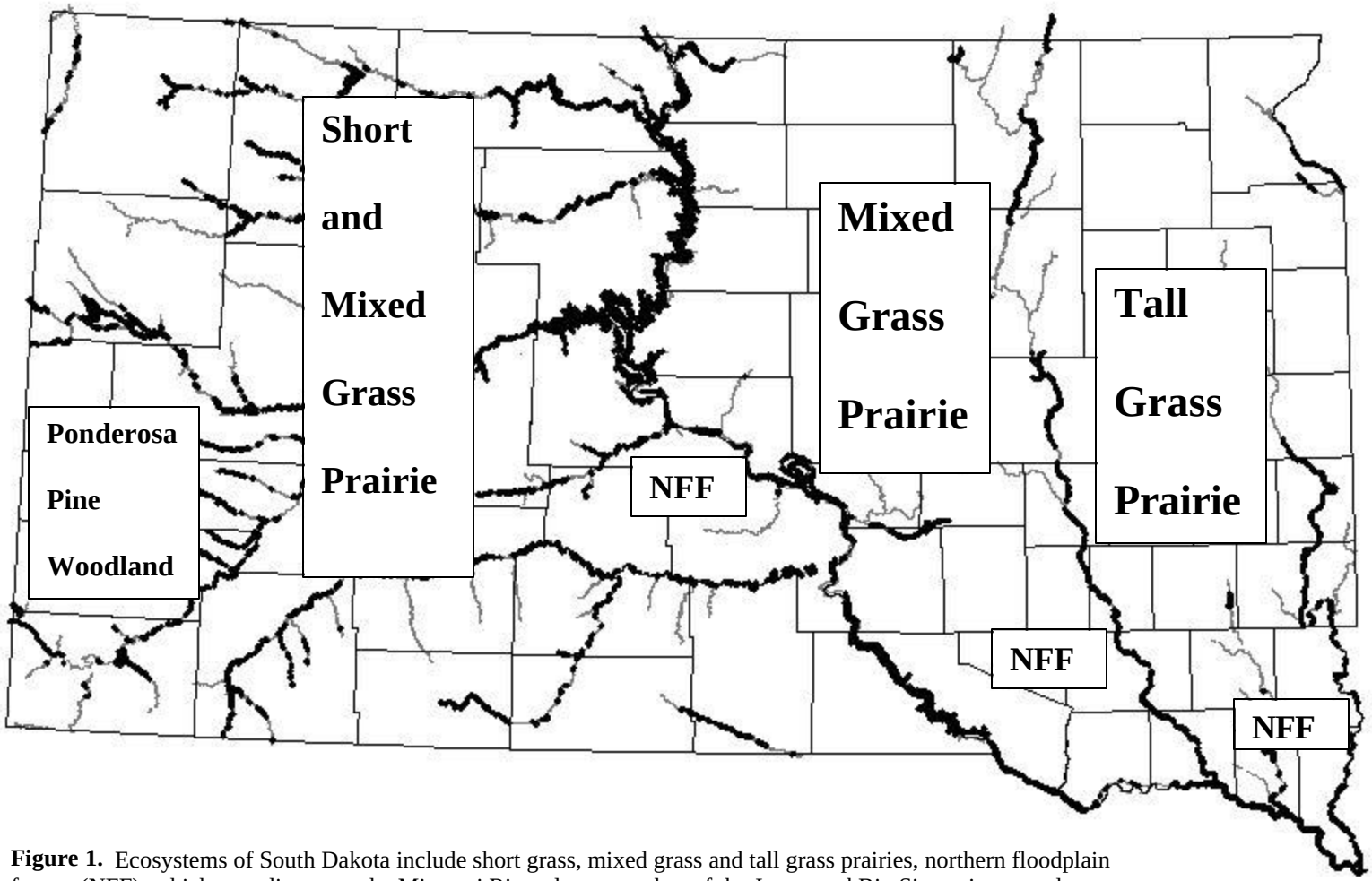


Figure 1. Ecosystems of South Dakota include short grass, mixed grass and tall grass prairies, northern floodplain forests (NFF); which are adjacent to the Missouri River, lower reaches of the James and Big Sioux rivers, and other Missouri River tributaries; and ponderosa pine woodland.

To narrow the focus of this research, specific rivers in South Dakota were selected based on three river otter habitat requirements. These characteristics included stream orders three through seven (larger rivers or streams) according to the Strahler Order stream order system (Murphy and Willis, 1996), permanent water flow, and low gradient (slower moving waters) (Mack, 1985; Bradley, 1986; Johnson and Madej, 1994; Reid et al., 1994; SDGAP, unpublished report, 2001). The selected stream reaches were the Big Sioux River, James River, Vermillion River, Missouri River, Little Minnesota River, Jorgensen River, North Fork of the Whetstone River, Moreau River, Grand River, Virgin Creek, Cheyenne River, Bad River, Medicine Creek, White River, Little White River, Rapid Creek, and Belle Fourche River (Figure 2).

METHODS

Status and Distribution

I contacted the South Dakota Natural Heritage Program for information on river otter sightings in South Dakota. The Natural Heritage Database is a sector of the Natural Heritage Program and serves to inventory and monitor threatened, endangered, and rare species in South Dakota. Furthermore, Indian tribes were contacted for information on reintroduction efforts and river otter sightings within the reservations. Landowners, trappers, and conservation officers provided additional information on river otter sightings within South Dakota.

River otter observation report forms were mailed to all conservation officers in South Dakota (Appendix A). The observation reports were used to record the areas

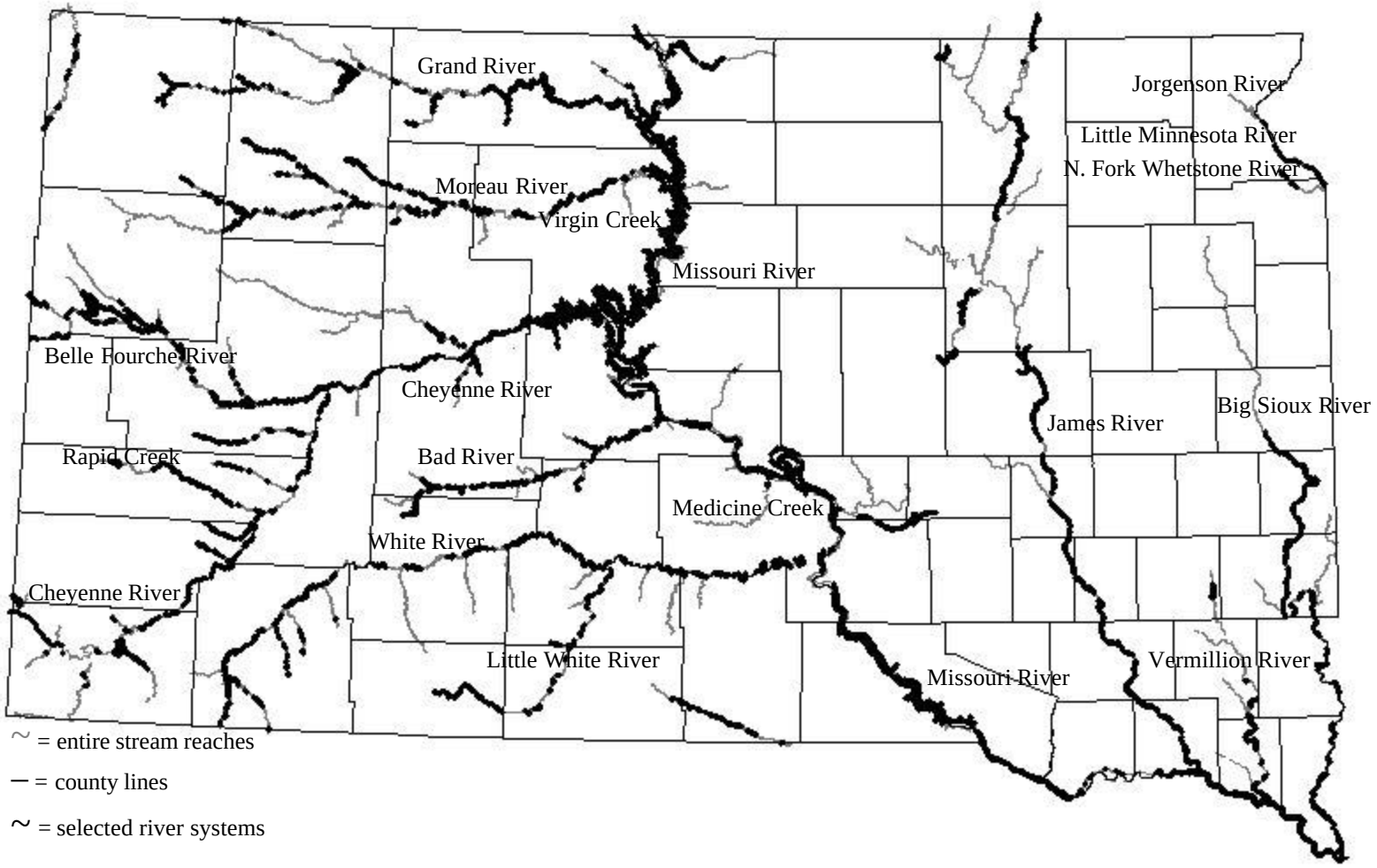


Figure 2. Selected stream reaches in South Dakota with rivers for river otter habitat study sites as determined by permanent water flow, stream orders three through seven, and low gradient.

where river otters had been sighted and to report detailed information about the sighting. Additionally, I searched for river otter sign along line transects while conducting habitat assessments on riparian areas of rivers throughout the state.

Habitat and Water Quality Assessment

I contacted biologists from Minnesota, Nebraska, Iowa, and Missouri to receive information on past river otter reintroduction efforts. This information helped establish habitat and water quality parameters that should be considered in seeking potential river otter habitat. Study sites were selected using information I collected from conservation officers, trappers, and biologists in addition to the GIS selected stream reaches map. Habitat availability, river accessibility, beaver activity, and past verified sightings were used as indicators of river otter habitat. Study sites consisted of one to four sites per selected river system (Figure 3; Appendix B). The length or size of the river system determined the number of study sites.

At each study site, I sampled one habitat transect, which was 50 m long and intersected with six 10 m perpendicular lines every 10 m. Habitat transects were less than five meters inland from the high water mark at each river. At each line intersection and endpoint along the habitat transect (18 points total), floral and faunal species were recorded (Figure 4). Also, I searched for river otter sign below the high water mark beside each river (Mowbray et al., 1976). Publications by the Great Plains Flora Association (1991), Johnson and Larson (1999), and Larson and Johnson (1999) were used to identify plant species, and publications by Cochran and Goin (1970),

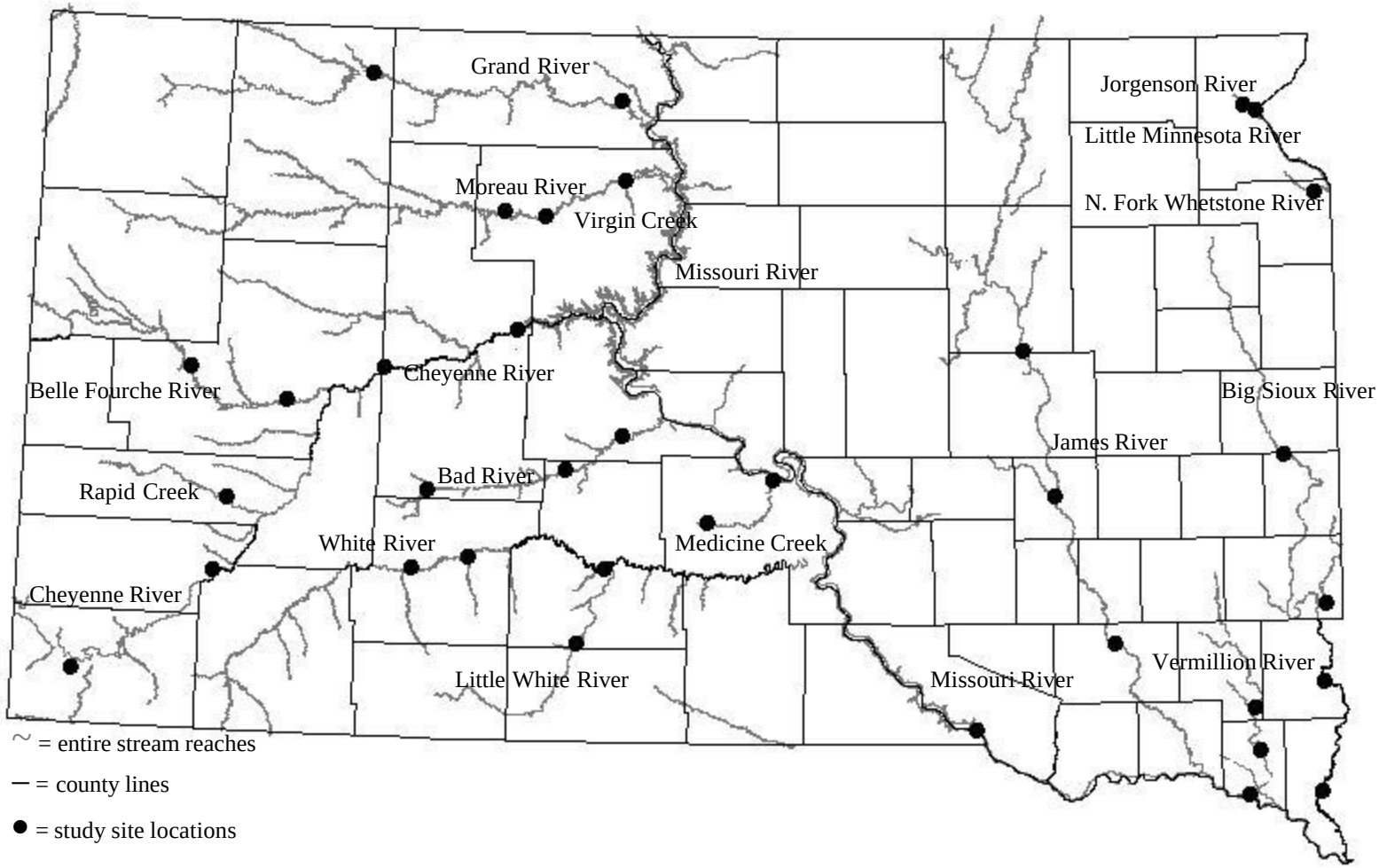


Figure 3. Study sites selected based on habitat availability, river accessibility, and beaver activity on South Dakota river systems sampled for river otter activity and riparian flora and fauna during summer of 2001.

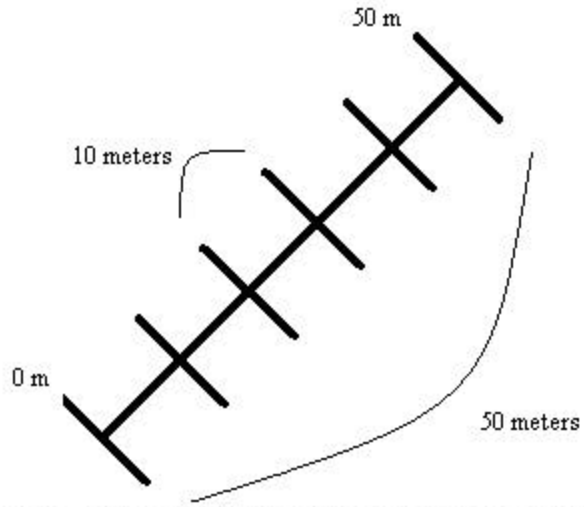


Figure 4. Line transect center line (50 m) and intersecting lines (10 m) used for habitat work.

Pennack (1989), Rezendes (1999), and Higgins et al. (2000) were used to identify animal species. In addition to recording floral and faunal species, I recorded the presence of streams, rivers, or wetlands associated with the study river or creek, presence of beavers (e.g., sign), percent of ground cover by undergrowth vegetation, percent of canopy cover by trees and tall shrubs, and Global Positioning System (GPS) location (Appendix C). Percent ground cover was segmented into graminoid species, forb species, shrub species, and other (e.g., litter). Percent canopy included the overgrowth vegetation (e.g., trees and tall shrubs). Percent ground and canopy cover were measured with a GRS™ densitometer which allows measurement of both canopy and ground cover at the 18 points along the line transects (GRS, 2001).

At each study site, I collected water samples to conduct water quality analyses. Samples were collected using a water sampler attached to a string, and water quality analyses were conducted with HACH© testing kits (HACH, 2002). Variables measured

were pH, nitrogen (nitrate-nitrogen [mg/l]), phosphorus (orthophosphate [mg/l]), dissolved oxygen (ppm), and alkalinity (methyl-orange [mg/l]) (Appendix C). Additional water measurements taken at each site were temperature (C) and secchi depth (m) (Appendix C).

Map surveys of stream reaches were conducted in spring. The land cover classification and stewardship map designed by the South Dakota Gap Analysis Project (2000) and the ecoregion map provided by United States Geological Survey (1998) were used to characterize stream reaches by land use and vegetative cover. I used land use and land cover information to aid in rating river systems for river otter habitat and to identify possible release sites.

I used existing fish census data to determine the prey available to river otters within each river system. In addition, I recorded other potential prey species while conducting the habitat transects. Fish census data were provided through past work on major river systems throughout South Dakota (Berry et al., 1993; Lott et al., 1993; Schmulbach and Braaten, 1993; Dieterman and Berry, 1994; Hampton and Berry, 1997; Dieterman and Berry, 1998; Loomis et al., 1999; Fryda, 2001; Milewski, 2001).

Once fieldwork was completed, I rated rivers based on the following criteria: 1) stream characteristics, such as varying water depth and suitable bank cover; 2) watershed features, such as presence of suitable wetlands nearby (1 km either direction from the study sites) and beaver populations; 3) water quality, 4) prey availability, such as fish populations and other aquatic prey species; and 5) other factors, such as private or public ownership. Each characteristic, listed under the five categories, was rated with a value of

one to five according to river otter requirements (Appendix D). Then, the five categories were added to produce an overall river rating. Data used to rate each river system included percent vegetative cover, number of plant species, water quality, number of fish species, number of other prey species, river otter sightings, and land cover/use maps. In this rating system, a higher number indicated the greater suitability for river otters. Also, I attempted to compare the variables I used to determine river ratings in South Dakota to the variables used in the river otter habitat suitability index (HSI) model (USFWS, unpublished report, 1985).

RESULTS

Status and Distribution

Thirty-four verified and three unverified river otter sightings were recorded prior to and during this study. Of the 34 verified river otter sightings, 12 sightings were reported from 1979 to 2001 to the South Dakota Natural Heritage Database and 22 sightings were received from South Dakota landowners, conservation officers, biologists, and trappers from 1998 to present. Some of the latter verified reports were not reported to the Natural Heritage Database. Three unverified river otter sightings were reported by landowners from 2000 to present (Table 1; Figure 5). Eighty-nine percent of the river otter sightings have occurred east of the Missouri River (Figure 5). There is a small population of river otters along the Big Sioux River, which is likely the result of the Flandreau Santee Sioux Tribe reintroduction of 17 river otters in 1998-1999 and an additional 17 river otters in 1999-2000 (Raesly, 2001; W. Hansen, Flandreau Santee

Table 1. River otter sightings reported in South Dakota from the Natural Heritage Database (*) (1979-2001), by biologists, and from the general public (1998 to present).

Verified (Y/N)	County	Township	Range	Section	Descriptive Location	No. of Times
Y	Brookings	109N	49W	30	Medary Creek	2
Y	Codington*	119N	52W	14	near Round Lake	
Y	Custer*	2S	5E	36	Iron Creek	
Y	Grant	121N	46W	34	Lake Albert	
Y	Grant	121N	46W	22	Whetstone River	
Y	Haakon*	1N	20E	23	Bad River	
Y	Hamlin	113N	51W	16	Big Sioux River	
Y	Hughes*	110N	79W	10	near Lake Sharpe	
Y	Hughes*	112N	80W	9	Spring Creek	
Y	Hughes	112N	80W	4	Spring Creek	
Y	Jerauld	108N	65W	35	Firesteel Creek watershed	
Y	Lincoln	100N	49W	35	Big Sioux River	
Y	Lincoln	97N	48W	12	Big Sioux River	
Y	Lyman	105N	77W	8	Medicine Creek	
Y	McCook*	101N	53W	35	Vermillion River	
Y	Minnehaha	101N	48W	16	Big Sioux River	
N	Minnehaha	102N	52W	29	Kindt WPA	
N	Minnehaha	102N	48W	3	West Pipestone Creek	
Y	Moody	107N	48W	22	Big Sioux River	3
Y	Moody	107N	48W	14	Big Sioux River	
Y	Moody	108N	50W	1	Big Sioux River	
Y	Moody	105N	49W	3	Big Sioux River	3
Y	Moody	106N	49W	34	Big Sioux River	
Y	Moody	106N	49W	22	Big Sioux River	2
Y	Moody	107N	48W	21	Big Sioux River	3
Y	Moody	107N	47W	20	Flandreau Creek	
Y	Moody	106N	49W	14	Big Sioux River	
Y	Moody	105N	49W	12	Big Sioux River	2
Y	Moody	108N	49W	8	Big Sioux River	
Y	Moody	108N	49W	6	Big Sioux River	
Y	Pennington*	1N	14E	17	Cheyenne River	
Y	Roberts*	128N	49W	28	Cottonwood Lake	
Y	Sanborn*	108N	62W	6	Sand Creek	
Y	Stanley*	6N	30E	25	near West Shore Ramp	
Y	Sully*	115N	81W	19	Little Bend	
Y	Union*	92N	49W	3	near Lake Nixon	
N	Yankton	93N	56W	20	near Gavins Point Dam	

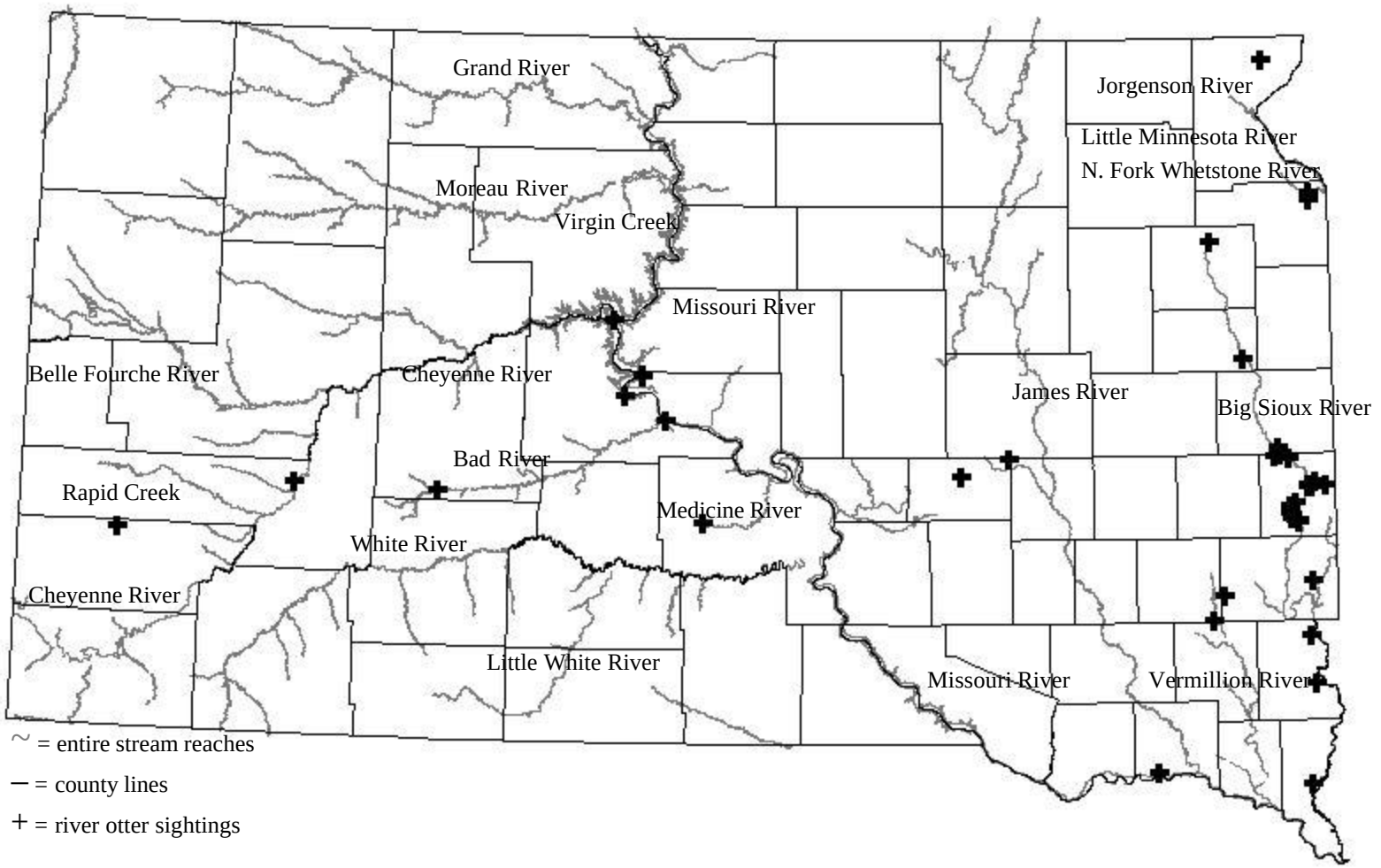


Figure 5. River otter sightings reported to the Natural Heritage Database (1979-2001), by biologists, and the general public.

Sioux Tribe, pers. comm.). The status of that population is unknown, although sightings have persisted for nearly five years.

While conducting habitat transects, river otter sign was found along the Big Sioux River at two locations, one at the Moody County study site and one at the Lincoln County study site. In both cases, imprints proximate to water in riparian zones represented river otter sign.

Habitat and Water Quality Assessment

Vegetation Characteristics

The most common plant families in riparian areas were Asteraceae (sunflower), Poaceae (grass), Fabaceae (bean), Salicaceae (willow), Rosaceae (rose), Vitaceae (grape), Aceraceae (maple), Lamiaceae (mint), and Asclepiadaceae (milkweed) (Appendix E). Percent canopy cover of trees and tall shrubs ranged from 0 to 29 (Table 2). Percent cover of graminoid vegetation ranged from 11 to 40, forbs ranged from 16 to 40, shrubs ranged from 3 to 24, and other (e.g., litter and ground debris) ranged from 0 to 26 (Table 2).

Water Quality

Secchi depth ranged from 0.01 m to 0.9 m. Dissolved oxygen ranged from 5.0 ppm to 11.0 ppm. Alkalinity ranged from 140 (methyl-orange) mg/l to 740 mg/l and pH ranged from 7.5 to 8.5 (Table 3). Phosphorus (orthophosphate) ranged from 0.7 mg/l to 6.3 mg/l and nitrogen (nitrate-nitrogen) ranged from 0.01 mg/l to 0.26 mg/l. Temperature ranged from 18 C to 29 C (Table 3).

Table 2. Percent tree and tall shrub canopy cover, percent ground (graminoid, forbs, shrubs, and other) cover, and plant species (number) comprising riparian vegetation on study sites along study river systems in South Dakota, 2001, based on habitat transect 50 m long intersected by lines 10 m long every 10 m.

River/Creek	% Canopy	% Ground				
		% Graminoid	*% Forbs*	*% Shrubs*	*% Other*	*# Plant Species*
Bad	18	29	28	18	7	23
Belle Fourche	16	24	21	21	18	26
Big Sioux	25	33	29	9	4	19
Cheyenne	8	37	39	8	8	20
Grand	0	39	39	7	15	29
James	20	29	23	22	6	19
Jorgenson	24	35	29	12	0	21
Little Minnesota	10	32	32	21	5	26
Little White	19	29	24	24	4	24
Medicine Creek	16	32	32	20	0	21
Missouri	24	30	27	16	3	30
Moreau	10	32	29	3	26	20
N. Fork Whetstone	6	40	40	7	7	29
Rapid Creek	20	24	16	24	16	26
Vermillion	29	24	21	10	16	22
Virgin Creek	28	11	33	6	22	17
White	21	26	21	16	16	23

Table 3. Water quality values for secchi depth, dissolved oxygen, alkalinity (methyl-orange), phosphorus (orthophosphate), nitrogen (nitrate-nitrogen), and temperature at study sites of river systems in South Dakota, 2001.

River/creek	Secchi Depth	Dissolved Oxygen	Alkalinity	Phosphorus	Nitrogen	Temperature
	m	ppm	mg/l	mg/l	mg/l	C
Bad	0.42	8.7	193	1.6	0.10	24.0
Belle Fourche	0.43	8.5	150	1.1	0.07	23.5
Big Sioux	0.27	7.5	245	3.4	0.20	25.5
Cheyenne	0.24	7.8	195	4.3	0.08	26.3
Grand	0.60	7.5	290	1.0	0.05	23.0
James	0.22	5.7	307	6.2	0.05	26.7
Jorgenson	0.24	8.0	240	2.0	0.09	23.0
Little Minnesota	0.52	7.0	220	1.3	0.10	22.0
Little White	0.17	9.0	200	3.3	0.04	24.0
Medicine Creek	0.21	6.5	240	2.5	0.08	23.5
Missouri	0.63	6.0	210	1.5	0.13	24.5
Moreau	0.03	8.0	240	2.0	0.03	25.5
N. Fork Whetstone	0.46	9.0	280	1.7	0.06	27.0
Rapid Creek	0.60	9.0	220	3.0	0.26	25.0
Vermillion	0.22	7.0	250	3.0	0.05	28.0
Virgin Creek	0.18	9.0	140	1.0	0.10	24.0
White	0.06	6.7	547	2.7	0.18	25.0

Prey availability

Only fish species with lengths of 20 cm and greater were included as prey base because of size selection of prey fish by river otters (Eddy and Underwill, 1982; Neumann and Willis, 1994). Number of fish families per river ranged from 5 to 14, while the number of fish species per river ranged from 9 to 33. Common fish families include Catostomidae (suckers), Cyprinidae (minnows over 20 cm), Ictaluridae (catfish and bullheads), Percidae (perch), Centrarchidae (sunfish), and Esocidae (pike). Number of other prey taxa per river ranged from 0 to 4. Common family representatives of other prey species include Ranidae (true frogs) and Anodontidae (mussels) (Appendix F).

River ratings and HSI

Habitat, water quality, and prey data were used to rate the study rivers for river otter habitat requirements. Information collected on percent cover, plant species diversity, other prey species, water quality, and fish species were used in combination with land cover, stewardship, and land use maps to determine overall ratings. Overall river ratings ranged from 60 to 75 points with maximum possible rating being 105 points (Table 4; Appendix G).

The HSI formula is as follows: $HSI = \frac{2\,(FCI) + ADI}{3}$, the formula for FCI is as follows: $FCI = (SIF \times SIC)^{1/2}$, and the formula for ADI is a line graph ($\leq$ 500 m [between water sources] = 1 and $\geq$ 3000 m [between water sources] = 0). Within the HSI formula three variables were considered, which included foraging habitat, cover habitat, and interspersion of aquatic systems (USFWS, unpublished report, 1985). FCI is the food cover index. The variables comprising the food cover index are SIF and SIC. SIF is the

Table 4. Overall river ratings (maximum rating of 105) of South Dakoka study rivers or creeks including each category rating (stream characteristics, watershed features, water quality, prey availability, and other factors [e.g., private or public ownership and stream accessibility]) based on a scale of one to five, with values closer to five indicating higher habitat suitability for river otters.

River/Creek	Rating	Stream Characteristics	Watershed Features	Water Quality	Prey Availability	Other Factors
Bad	75	32	14	11	8	10
Big Sioux	74	35	15	8	7	9
Missouri	73	28	16	10	5	14
James	72	32	16	8	8	8
North Fork Whetstone	72	28	19	11	4	10
Little White	69	28	18	10	4	9
Vermillion	68	29	14	10	9	6
Cheyenne	68	31	14	10	4	9
Jorgenson	68	26	19	10	6	7
Belle Fourche	67	30	12	12	6	7
Moreau	67	26	15	11	7	8
Grand	65	29	13	11	7	5
Medicine	64	25	11	10	9	9
Virgin	63	20	16	11	7	9
Little Minnesota	62	24	15	10	6	7
Rapid	61	26	13	7	4	11
White	60	31	11	6	3	9

suitability index for food, which estimates the prey productivity of the water system. SIC is the suitability index for cover, which measures percent terrestrial vegetative cover less than or equal to five meters from the edge of the water. The other variable involved with the HSI is the ADI. ADI is the interspersion of aquatic systems, which measures the distance between aquatic systems. Habitat suitability index models are used to establish habitat suitability ratings between 0 and 1 where values near one indicate habitat more suitable for river otters.

The river rating system I used incorporated suitable nearby watercourses (e.g., tributaries and wetlands), food diversity (e.g., number of fish and other aquatic prey species), and suitable bank cover (e.g., percent canopy and ground cover and number of plant species), which is similar to the HSI. Five categories and 21 subcategories were considered within the river rating system. Each subcategory was given a rating between one and five, depending on river otter habitat requirements. The highest river ratings indicated the rivers most suitable for river otters.

DISCUSSION

Status and Distribution

There was no indication of a remnant population of river otters in South Dakota according to river otter sightings. Only two sightings, which occurred before the late 1980's, may be attributed to river otters from established populations traveling into South Dakota.

The greatest number (20) of river otter sightings occurred in Moody County, which is the location of the Flandreau Santee Sioux Tribe. In 1998-1999 and 1999-2000, the Flandreau Santee Sioux Tribe reintroduced a total of 34 river otters into the Big Sioux River near Flandreau, South Dakota, as part of a cultural goal to restore a native species to Tribal Lands (Raesly, 2001). Released river otters were not marked for post-release monitoring, though sightings of river otters have persisted for several years. Sightings of reintroduced river otters along the Big Sioux River during three occasions consisted of groups of three to four river otters. Usually groups of three to four river otters comprise family groups, which consist of the mother and her young. As a result, some reintroduced river otters may have have reproduced along the Big Sioux River.

Habitat and Water Quality

Good river otter habitat includes rivers with adequate riparian vegetation, including canopy and ground cover (Mowbray et al., 1976). The riparian vegetation along the rivers in South Dakota consists primarily of graminoid and tree species. The percent cover, particularly graminoid cover, along most rivers seems to provide sufficient cover for river otter use, e.g., due to high percent cover values. Presence of adequate ground cover, especially graminoid species, is more important than forest canopy cover due to the habits of river otters (Waller, 1992). However, Waller (1992) stated that the presence of tree canopy is important in winter. Ninety-three percent of sites occupied by river otters in northwestern Montana had tree canopy, primarily consisting of birch and

cottonwood trees (Waller, 1992). Consequently, rivers with higher percent canopy and ground cover provide better river otter habitat.

The banks of rivers in South Dakota ranged from gently to steeply sloped, but most rivers were moderately sloped and possessed animal bank dens, primarily coyote (*Canis latrans*) and beaver. River otters use riparian areas with low to moderate bank slopes that contain bank dens and other habitat created by beavers (Malville, 1990; Andelt, 1992; Beck, 1992; Waller, 1992). Beaver activity can be found on nearly every major river system in South Dakota (Smith, 2001). Therefore, ample den-sites should be available for river otters. In addition, beavers produce lodges and cut down trees, which create in-stream structures. River otters typically select areas with waterway obstructions for resting and feeding areas (Dronkert-Egnew, 1991).

Concerns for river otter survival are greater during winter in the Northern Plains. Nevertheless, winter snowfall and ice-covered streams do not seem to affect the survival of river otters in northern states (Toweill and Tabor, 1982; R. Andrews, Iowa Department of Natural Resources, pers. comm.). In South Dakota, large rivers freeze over, but beaver bank dens are typically present to allow for den-sites and access to water for foraging. Ice on rivers and streams may provide cover for river otters. Waller (1992) reported that ice-covered streams were an important source of cover for river otters, and river otters more frequently used waterways with 100% ice-cover.

River otters select areas with low human disturbance or areas more remote and pristine, if available (Darrow, 1986; Griess, 1987; Dronkert-Egnew, 1991). South Dakota provides numerous river reaches with minimal human impact, especially in the western

portion of the state. Conversely, rivers in the eastern portion of the state, such as the Big Sioux, James, and North Fork of the Whetstone, while not as remote, have less than 20 percent of adjacent lands riparian areas without human impact to allow river otter survival.

River otters utilize river systems that are not highly polluted (Darrow, 1986; Griess, 1987), and river systems in South Dakota appear to have adequate water quality. However, water quality is more important to prey species than river otters (Beck, 1992). Based on water quality measurements, rivers in the northeast and extreme west portion of South Dakota had the highest water quality ratings (e.g., North Fork of the Whetstone River and Belle Fourche River), while rivers in the southwest had the lowest water quality ratings (e.g., White River and Rapid Creek).

Alkalinity, a measure of salt content, has a direct effect on freshwater fish species within South Dakota rivers (Murphy and Willis, 1996). Rivers in the south central and north central portions of the state had high alkalinity due to soils in those areas. However, fish populations are healthy and should provide sufficient food to support river otters in alkaline areas.

Turbid water conditions are a concern for river otters seeking prey in river systems. Turbidity affects the hunting efficiency of river otters but does not preclude their use of habitat (Beckel, 1990). River otters should be able to hunt effectively in most rivers of South Dakota.

Although only one measurement of dissolved oxygen was taken at each sample site, no rivers were below 5 ppm. Dissolved oxygen is highly variable throughout the

year. However, numerous fish species were present in all rivers indicating that dissolved oxygen may be sufficient to sustain adequately diverse fish populations.

A limiting factor for river otter survival is prey base. All South Dakota river systems that were studied seemed to provide a sufficient prey base for river otters, but biomass measurements were not available. Fish species present in most rivers included *Ameriurus* spp. (bullhead), *Ictalurus* spp. (catfish), *Micropterus* spp. (bass), *Poxomis* spp. (crappie), *Cyprinus carpio* (common carp), *Carpiodes carpio* (river carpsucker), *Lepomis macrochirus* (bluegill), *Perca flavescens* (yellow perch), *Esox lucius* (northern pike), and *Catostomus commersoni* (white sucker). Rivers or creeks with the most diverse prey base were the James River, Vermillion River, and Big Sioux River.

Exact distances were not measured between nearby watercourses and study rivers/creeks, food productivity data were not available, and vegetative heights were not measured to evaluate the rivers in the river rating system. These values were required to obtain HSI values (USFWS, unpublished report, 1985). As a result, comparisons among variables from the river rating system and HSI were conducted as opposed to comparing numerical HSI index values and river ratings.

In comparing the variables from the HSI model and my river rating system, the HSI used fewer variables than my rating system. My rating system included additional variables besides food, cover, and nearby water sources as suggested by biologists and literature (Johnson and Madej, 1994; D. Hamilton, Missouri Department of Conservation, pers. comm.; T. Serfass, Frostburg State University, pers. comm.). Variables not considered in the HSI included subcategories such as beaver activity, intensity of beaver

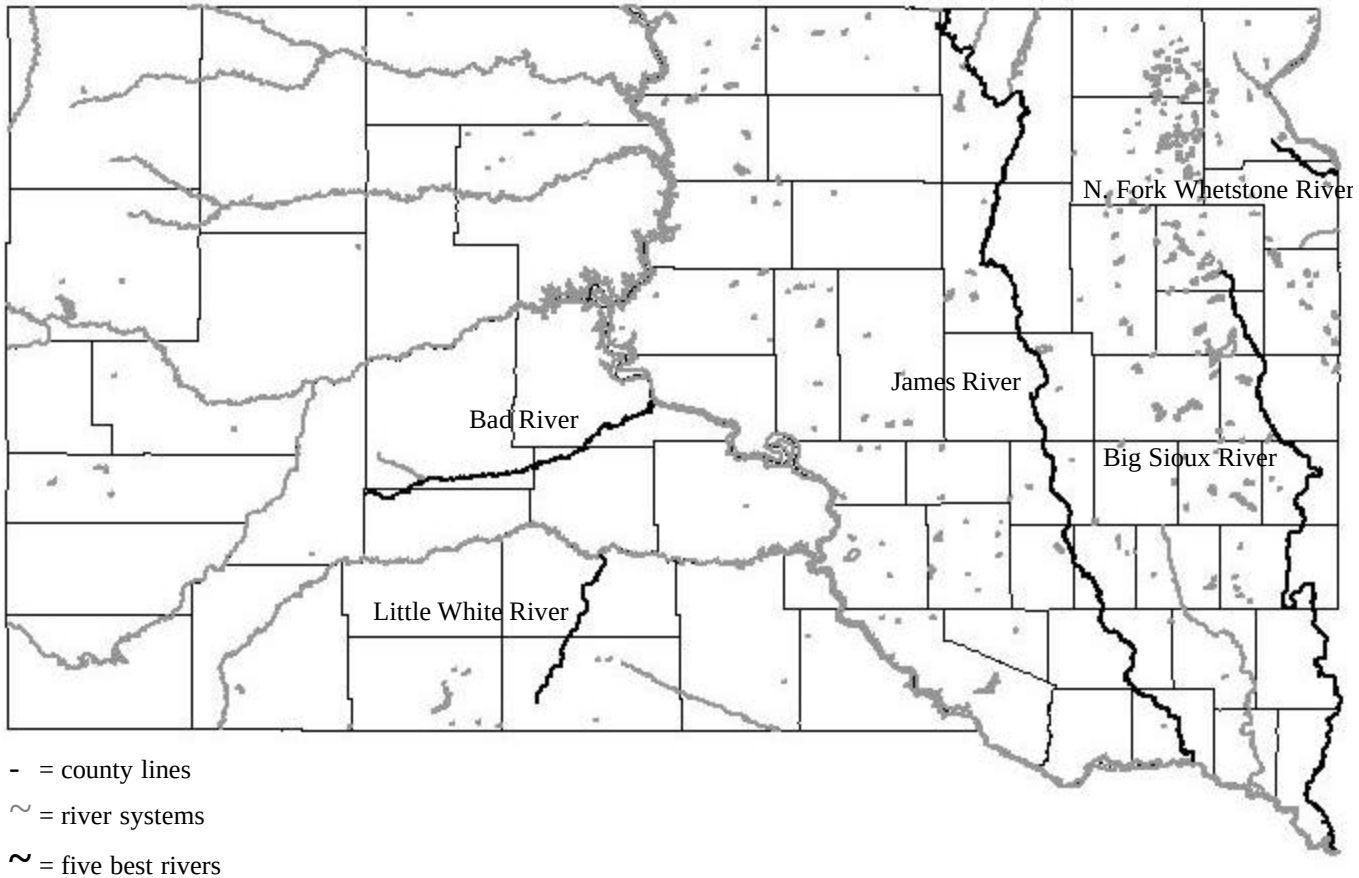
trapping, varying water depths, low stream gradient, permanence of water, and water quality values. In addition, the habitat suitability index model strictly measured the habitat and its suitability for river otters. My rating system considered habitat suitability of rivers or creeks for river otter use but also integrated other factors, such as private or public landownership and stream accessibility, for the purposes of reintroducing river otters in South Dakota.

Selected Rivers for River Otter Release

Most of the rivers in South Dakota appear to provide adequate habitat for river otter use. Nevertheless, I believe five rivers with the highest ratings offer the best opportunity for river otter survival due to stream characteristics and prey availability. These include the Bad River, Big Sioux River, James River, North Fork of the Whetstone River, and Little White River (Figure 6). The Missouri River also was rated high, but I excluded it as a river otter release site because of its extreme size and status as a major river drainage versus other selected rivers (tributaries). Also, much of the Missouri River is impounded, which makes linear movements difficult for river otters. It is possible that river otters may move to sections of the Missouri River upon their release.

Bad River

The Bad River received the highest overall rating (75) among the major river systems in South Dakota. Riparian vegetation consists of percent canopy and graminoid cover of 47 and contains primarily Asteraceae (sunflower), Cyperaceae (sedge), Poaceae (grass), and Fabaceae (bean) families. Bank slopes are moderate to steep, and human



- = county lines

~ = river systems

~ = five best rivers

Figure 6. Five best rivers in South Dakota that provide the best river otter habitat and prey availability. These rivers are recommended for release sites as part of the river otter reintroduction protocol.

impact through grazing practices to riparian areas is moderate. Water quality is high, according to nitrogen, phosphorus, alkalinity, and turbidity values, relative to other study rivers or creeks. An adequately diverse prey base of fish and amphibians is present within the Bad River. Ten fish species are present in the Bad River with common fish families consisting of Ictaluridae, Centrarchidae, and Catostomidae. Fish population levels fluctuate with water levels, as water levels increase fish populations increase. Water ranges from shallow to moderate depths supplying ample feeding areas. Seven suitable tributaries are present, although these watercourses may dry out during summer months. Two of three (67%) of the study sites indicated that beaver are present, and beaver trapping is moderate according to state and private trapping entities.

Big Sioux River

The Big Sioux River received the second highest rating (74) among the major river systems in South Dakota. Fifty-eight percent of riparian vegetation consists of canopy and graminoid cover, which is among the highest cover percentages relative to other study rivers or creeks. Common plant families comprising riparian vegetation include Asteraceae, Poaceae, Aceraceae (maple), Lamiaceae (mint), and Cyperaceae. Bank slopes are moderate. Human impact through urban development and agriculture are prevalent throughout this river. High nitrogen and phosphorus levels indicate that water quality is low in the Big Sioux River in relation to other study rivers or creeks. The survival of many fish species indicates that river otter survival should not be affected by lower water quality. Thirty fish species are found within this river, and common fish families are Percidae, Centrarchidae, Ictaluridae, Catostomidae, and Cyprinidae. Shallow

to moderate water depths supply ample feeding areas. Four suitable tributaries are available along the Big Sioux River providing areas for river otter dispersal. Although the Big Sioux River is located within the prairie pothole region, minimal adjacent wetlands are found within 1 km upstream and downstream from the study sites. Beaver activity at three of four (75%) of the study sites indicated that den-sites and resting areas within lodges or banks are present for river otter use. Intensity of beaver trapping is moderate.

James River

The James River tied with the North Fork of the Whetstone River as the third highest rated river (72). Riparian habitat consists of canopy and graminoid cover with a combined percent value of 49, and common plant families include Asteraceae, Lamiaceae, Poaceae, Rosaecae (rose), and Salicaeae (willow). Human impact, such as agriculture, is prevalent throughout the James River. Bank slopes are moderate to steep. Water quality of the James River is low relative to most study rivers or creeks in South Dakota; secchi depths are relatively low and phosphorus (orthophosphate) levels are high. Although water quality is low, prey survival including fishes, mussels, and amphibians is not affected. Thirty-three fish species are found in the river, which is the highest fish diversity among all study rivers or creeks. Common fish families include Cyprinidae, Catostomidae, Ictaluridae, Centrarchidae, and Percidae. Water ranges from shallow to moderate depths supplying ample feeding areas. Eight suitable tributaries are present along the James River. Being located in the prairie pothole region, the James River has an average of one to two nearby wetlands within 1 km upstream and downstream from

the study sites. At three of three (100%) of the study site locations beaver activity, in the form of lodges, chews, bank dens, and footprints, indicated that beaver are present in the James River. And, intensity of beaver trapping is moderate.

North Fork of the Whetstone River

The North Fork of the Whetstone River received the third highest river rating (72) along with the James River. Riparian vegetation appears to provide ample cover. Percent canopy and graminoid cover measures 46, and common plant families include Asteraceae, Fabaceae, Poaceae, Vitaceae (grape), and Lamiaceae. Bank slopes are steep to moderate, and human impact, such as agriculture, is moderate. Water quality is among the highest of the study rivers and creeks in South Dakota. Nitrogen, phosphorus, and alkalinity levels are low, while secchi depths are relatively high. The river contains a sufficiently diverse prey base. Ten fish species are present in the Minnesota River watershed, and common fish families include Percidae and Cyprinidae. Clear water with a rocky bottom and shallow to moderate depths indicates good foraging habitat. Because the North Fork of the Whetstone River is located in the prairie pothole region, additional habitat is available for river otters. Numerous adjacent wetlands within 1 km upstream and downstream from the study sites are present along the North Fork of the Whetstone River. Beaver activity at one of one (100%) of the study sites indicated that habitat is available for river otter use. Beaver trapping pressure is low.

Little White River

The Little White River is the fourth rated river (69). Percent canopy and graminoid cover is 48 and common plant families include Asteraceae, Fabaceae, Poaceae,

and Vitaceae. Banks range from steep to gentle inclines throughout the Little White River. Livestock grazing is the primary land use along the Little White River. Water quality is high in relation to most of the study rivers or creeks. Nitrogen, phosphorus, and alkalinity values are relatively low as well as secchi depth. Eleven fish species were found in the Little White River, which appears to constitute an adequately diverse prey base. Common fish families include Percidae and Catostomidae. Water depths vary from shallow to moderate, which appears to provide adequate feeding areas. Beaver activity is evident throughout the Little White River; beaver activity at one of one (100%) of the study sites indicated the presence of potential river otter habitat. Beaver trapping pressure is moderate.

Potential for River Otter Reintroduction

South Dakota provides quality river systems with ample habitat for the survival of river otters. As a result, river otters should survive if a reintroduction effort is initiated. Natural expansion of river otters may occur in eastern South Dakota, but it is difficult to predict whether river otters would expand naturally into western South Dakota. Therefore, I recommend a river otter reintroduction effort on five different river systems in South Dakota, which would include the five highest rated river systems, excluding the Missouri River. This effort would help restore this native species to its historical range and hopefully allow the development of a river otter management program in the future.

River otter reintroduction efforts in nearby states have been successful. The Minnesota Department of Natural Resources conducted a river otter reintroduction in the

early 1980's, and twenty-four river otters were released in southern Minnesota. The current river otter population, including remnant and reintroduced populations, is approximately 12,000 river otters statewide. A regional management plan has been implemented, and nearly 2,000 river otters are harvested for pelts each year (MNDNR, 2002). Currently, a graduate student is conducting a river otter assessment in southern Minnesota.

The Iowa Department of Natural Resources conducted a river otter reintroduction in the late 1980's, and recently the Department has removed the river otter from state threatened status. Originally, 261 river otters were released in major watersheds throughout Iowa. River otters have been reported in 94 counties and determined to be reproducing in 75 counties (R. Andrews, Iowa Department of Natural Resources, pers. comm.). Currently, the department is discussing the formation of a river otter management plan.

The Missouri Department of Conservation also conducted a successful river otter reintroduction. The reintroduction in Missouri occurred for a decade beginning in the early 1980's. During this period, 845 river otters were released in suitable river systems throughout Missouri. Currently, the river otter population is estimated near 30,000 river otters with an implemented river otter management plan (D. Hamilton, Missouri Department of Conservation, pers. comm.).

The Nebraska Game and Parks Department conducted a river otter reintroduction in the late 1980's. One hundred fifty-nine river otters were released in river systems throughout Nebraska. The status of the state's river otter population is unknown,

although biologists suspect river otters are reproducing (R. Lock, Nebraska Game and Parks Commission, pers. comm.). The river otter is still listed as an endangered species in Nebraska.

Reintroduction Protocol

If a river otter reintroduction is initiated, I have the following recommendations. Foremost, public relations work should be conducted to obtain public support with the reintroduction and to inform the public of the ecology of the river otter and river otter reintroduction procedures.

Public Relations

Public relations work is important to earn support for the river otter reintroduction and obtain assistance from landowners, biologists, trappers, and the general public with the protection of released river otters (Andelt, 1986; Hamilton et al., 2000). News releases, public meetings, and direct contact with individuals will help achieve support and attain assistance from various groups by providing information about the project including the ecology, status, and survival of the river otter in South Dakota. Andelt (1986) used these methods in Nebraska, and public involvement and support were high.

South Dakota conservation officers and biologists were contacted to determine the overall support of a river otter reintroduction in South Dakota. Most biologists were supportive of the river otter reintroduction. Biologists who did not support a river otter reintroduction stressed their concern for the presence of adequate river systems and the effects of river otters on the fisheries of the river. Polechla (1990) and Serfass et al.

(1990) suggested that river otters catch fish in proportion directly to abundance and indirectly to swimming ability, which may be beneficial to game fisheries (Melquist and Dronkert, 1987).

Release Sites

The release sites for river otters should be selected based on stream accessibility and habitat availability (Melquist and Hornocker, 1983). Specific areas of the five river reaches may provide better habitat, and these areas should be used for release sites. For instance, the lower reaches of the Big Sioux and James River provide better habitat, the eastern reaches of the Bad and North Fork Whetstone River provide better habitat, and the northern and western reaches of the Little White River provide better habitat than the entire river reach. One release site should be selected per river. Therefore, five release sites (James River, North Fork of the Whetstone River, Big Sioux River, Bad River, and Little White River) within five different watersheds should be selected.

Release Stock Sources

The criteria for selecting the source of river otters includes availability of river otters, genetic issues, and past successes of using a specific source (Raesly, 2001). Missouri received their river otters from Louisiana, as did the Flandreau Santee Sioux Tribe. These river otters have adapted well in Missouri and in other states. Reintroductions should utilize animals from the nearest viable population to minimize genetic differences between subspecies (Berg, 1982; Serfass et al., 1998). I recommend obtaining river otters from Missouri since South Dakota's river otters are the same subspecies (*L. c. interior*) as river otters from Missouri and Louisiana (Hall, 1981). The

Missouri Department of Conservation would provide South Dakota with river otters for approximately $200 each (D. Hamilton, Missouri Department of Conservation, pers. comm.).

Number of River Otters to Release

The number of river otters released in South Dakota should be at least 100. I suggest a total of 120 river otters released in the state. At each release site, 20 to 30 river otters should be released. The sex ratio at each release site should slightly favor females (Berg, 1982; Serfass et al., 1998). The Bad River, Big Sioux River, and North Fork of the Whetstone River should have 20 river otters released per site, while the James River and Little White River should have 30 river otters released per river. Due to past reintroduction efforts, the Big Sioux River should be selected last among the five release sites.

Release Length and Time

River otters should be released over a two-year period. The first year, 50 river otters should be obtained and released at two selected sites (Little White River and Bad River). The second year, 70 river otters should be obtained and released at three selected sites (James River, North Fork of the Whetstone River, and Big Sioux River). Timing of release depends on the availability and arrival of river otters. A late summer or early fall release is ideal, although river otters may be released in fall, winter, or spring (Andelt, 1986; Darrow, 1986). Guidelines include reducing capture-release holding and handling time and, in spring releases, release times should be scheduled later in the season (Darrow, 1986). By following these guidelines, stress related to translocating can be

minimized. In South Dakota, early fall is the preferred release time based on favorable weather patterns.

Handling and Translocating River Otters Selected for Release

Stresses associated with capture, handling, and translocating river otters can cause mortalities. River otters should be shipped either via vehicle or aerial transport, depending on the number of river otters and the cost and distance of the transport. Once river otters are received, they should be transferred to a handling box, which is a modified Melquist and Hornocker (1979) squeeze-box designed and described by McCullough et al. (1986). This box helps minimize stress, reduce mortalities as a result of restraint, and allows the administration of an immobilizing drug for radio-implant surgery and/or transport. During translocation, minimal human contact is advised.

River otters should be released upon their arrival, after they have been fitted with ear or foot web tags or radio-transmitters (Darrow, 1986). I recommend monitoring reintroduced river otters using radio-implant transmitters to determine the success of the reintroduction and to determine survival and reproduction rates. A veterinarian should perform the implant surgery and properly monitor the river otter before its release. Before surgery is conducted, river otters should be placed in holding pens and monitored for three to five days, the length of time it takes for river otters to begin feeding (Serfass et al., 1993). During surgery, the radio implant is placed in the ventral abdomen, and the immobilizing chemical should be diazepam in combination with ketamine (Elmore et al., 1985). After surgery, the river otter is placed in a holding pen, which should measure 1.5 m wide, 2 m long, and 2.5 m tall and provide a small den area (Mack et al., 1994). River

otters can be released within 24 to 72 hours after surgery and after sex, age, weight, and morphological measurements are recorded (Mack et al., 1994).

Duration and Techniques of Monitoring Released River Otters

Short-term and long-term monitoring of the reintroduced river otter population should occur. Short-term monitoring (two years) can be conducted using radio-implants. Long-term monitoring can be conducted by observing river otters with ear or foot-web tags in annual surveys. Annual surveys include identification of individual river otters through ear or foot-web tags while conducting line transect surveys and can be conducted by students or technicians through various funding sources. Additionally, bridge surveys and winter aerial surveys can help locate river otters by recognizing field sign. Long-term monitoring will help determine demographics of reintroduced river otters in South Dakota over an extended period as most successful reintroductions do not show population growth for approximately five years (Ralls, 1990).

Possible Problems with a Reintroduction

Three publics may express opposition to the reintroduction of the river otter. These include landowners, anglers, and trappers. Landowners may feel that the presence of river otters will affect the use of their land. River otters are not known to be problematic to the livelihood of landowners, although river otters can be considered a nuisance if populations become too large. No depredation occurs to livestock or agriculture as a result of high river otter populations. In most areas of South Dakota, river otters will probably not overpopulate.

Anglers may suspect river otters as a problem in reducing game fisheries due to their piscivorous lifestyle. River otters are not known to affect the fisheries unless river otter populations become too large, which is a cause for concern in Missouri. Bass are river otters' primary prey species in some streams of Missouri. Because of potential conflicts between river otters and trout fisheries, I do not recommend releasing river otters in the Black Hills. It is possible that river otters will move into the Black Hills, but no influx of river otters to the Black Hills has been observed from Wyoming.

The Eastern South Dakota Trappers Association and the Western Furharvesters of South Dakota showed little support for a river otter reintroduction. On the other hand, some trappers displayed support but stressed concerns for possible problems attributed to the presence of river otters, such as competition with mink populations and restrictions on beaver trapping. If future opportunity exists to trap river otters for financial gain (from pelts), then trapping organizations along with trappers may, in turn, support a river otter reintroduction.

Anticipated Costs of a Reintroduction

Year 1 (Public Work and Site Selection):

Public relations work and release site selection	$2,000
	Total = $2,000

Year 2 (Reintroduction):

Obtain river otters	
-50 river otters at $200 per river otter	$10,000
Transport river otters and contact trappers (state and private)	$5,500

Hold and examine river otters plus radio-transmitters and implants

-holding pens and veterinarian examination

-15 river otters (5 per site) at $400 per river otter $11,000

Monitoring by graduate student $15,000

Technician $5,000

Total = $46,500

Year 3 (Reintroduction):

Obtain river otters

-70 river otters at $200 per river otter $14,000

Transport river otters $5,000

Hold and examine river otters plus radio-transmitters and implants

-holding pens and veterinarian examination

-15 river otters (5 per site) at $400 per river otter $11,000

Monitoring by graduate student $15,000

Technician $5,000

Total = $50,000

Year 4 (Long-term monitoring):

Winter aerial surveys $3,000

Monitoring by graduate student $15,000

Technician $5,000

Total = $23,000

Year 5 (Long-term monitoring):

Winter aerial surveys	$3,000
Monitoring by graduate student	$15,000
Technician	$5,000
	Total = $23,000

Total Cost for Five Year Project = $ 144,500

Recommendations

Trapping Recommendations

Implementing trapping restrictions, especially on beaver trapping, would be difficult and probably somewhat controversial. Instead, trapping techniques specified to avoid river otters should be recommended. Indiana and Nebraska used trapping recommendations rather than implementing trapping restrictions. These states recommend specific trapping techniques to avoid river otters while trapping beavers. Recommendations of different trapping techniques include caster mound sets, footholds, and snares with large loops (9" to 10"). Moreover, traps should be placed in areas that avoid beaver dam crossovers, den house entrances, and lodges (S. Huber, South Dakota Game, Fish and Parks, pers. commun.). By using different trapping techniques and placement, river otter mortalities can be reduced. Use of conibears is only recommended in areas with minimal river otter activity. If 330 conibear traps are used, the triggers should be placed straight down near the sides of the jaws to avoid river otters.

Management Plan

If river otter reintroduction in South Dakota is successful, a management plan should be written and implemented to maintain a stable but viable river otter population. The management plan will be dependent on the adaptability of the reintroduced river otter population. Most states with successful river otter reintroduction efforts initiated a fall/winter trapping season, usually from October or November through January or February, and enforced a limit on the number of river otters taken by trappers.

CONCLUSION

South Dakota provides river systems with moderately good habitat for river otter use. Based on the results of my study, I determined that it is feasible to conduct a river otter reintroduction in South Dakota. Public support may be a concern. I discussed and selected the five best rivers for river otters as reintroduction sites, although river otters could possibly survive in additional rivers or areas of the state, such as the Vermillion River. Upon the initiation of river otter reintroduction, specific procedures should be followed to ensure their survival. The most important step is involving the public, so biologists may educate and obtain support for the reintroduction. The primary goal of the Natural Heritage Program is to employ wildlife management techniques to maintain all native flora and fauna along with related habitats. By initiating a reintroduction as part of a commitment to wildlife, the added presence of a once native South Dakota species, the river otter, will help diversify South Dakota fauna and restore a protected species to its historical range.

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Appendix A. River otter observation reports.

Observations of River Otters

Please fill out one of these forms for each river otter sighting within your county. I would appreciate if the form(s) for the sightings in your county are completed and sent to the forwarding address by March 22, 2002.

Date of sighting (mo/day/yr): _____

Type of sighting (incidental capture (explain), road kill, visual, scat, tracks, slides, other (explain), etc.): _____
_____
_____

Number of otters: _____

Was (were) the otter(s) dead or alive? _____

Location of sighting (township, range, section, county): _____
_____

Town nearest to sighting: _____

Waterbody/waterway of the sighting or nearest to the sighting: _____

Name and address of observer(s): _____
_____
_____

Submitted by: _____

Comments:_____
_____
_____
_____

Appendix B. UTM (Universal Transverse Mercator) coordinates of study site locations per river or creek.

RIVER/CREEK	NORTHING	EASTING
Bad	4905352	374347
Bad	4889290	354194
Bad	4877878	282056
Belle Fourche	4627800	649477
Belle Fourche	4920505	708819
Big Sioux	4729116	696661
Big Sioux	4789746	697168
Big Sioux	4894503	678899
Big Sioux	4825307	698361
Cheyenne	4795759	617139
Cheyenne	4837756	669931
Cheyenne	4934238	262306
Cheyenne	4951569	324353
Grand	5070620	717718
Grand	5057559	372252
James	4942345	557684
James	4806352	600277
James	4874174	572415
Jorgenson	5033566	662767
Little Minnesota	5053530	665618
Little White	4806669	351379
Medicine	4881799	442252
Medicine	4864115	399499
Missouri	4766622	536862
Missouri	4736847	663177
Moreau	5006878	318708
Moreau	5003996	337256
N. Fork Whetstone	5018418	696831
Rapid	4864772	684157
Vermillion	4776799	665413
Vermillion	4757725	667464
Virgin	5020761	374226
White	4842172	274951
White	4847014	301049
White	4841894	364198

Appendix C. Data sheets used to evaluate major rivers in South Dakota.

River Habitat Measurements Report

Stream/River/Wetland Name:_____.

Descriptive Location:_____. Date:_____. Time:_____.

Stream Characteristics:
densitometer reading:
ground_____
_____
_____
canopy_____
vegetation along transect:
_____
_____
_____
_____
_____
_____
faunal species/species sign along transect:
_____
_____
_____
_____
_____
otter presence/otter sign along transect:
_____
_____
_____
_____
_____
_____
_____ temperature reading (ºC)
_____ turbidity (m)

Water Quality:
_____ dissolved oxygen (ppm)
_____ nitrogen (mg/l)
_____ phosphorus (mg/l)
_____ pH
_____ alkalinity (mg/l)

Appendix C. Continued.

Other Comments (such as weather, appearance of water, presence of trash):

_____
_____
_____
_____
_____

Appendix D. River rating forms and methods used to evaluate major rivers in South Dakota.

River Rating Form

Stream/River/Wetland Name:_____.

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitaility. Rates were based on data collected and available.

Stream Characteristics:
_____ varying water depths
_____ slow velocity and low gradient
_____ turbidity (secchi depth)
_____ presence of stream meanders
_____ suitable bank cover
_____ presence of structures, such as logs (along bank & in the stream)
_____ permanence of water supply
_____ species diversity (plants and animals)

_____ Total

Watershed Features:
_____ presence of wetlands nearby
_____ presence of beaver populations (dens, scat, chewed woody vegetation)
_____ intensity of beaver trapping
_____ human impact on watershed
_____ presence of suitable tributaries

____ Total

Water Quality:
_____ nitrogen
_____ phophorus
_____ alkalinity

____ Total

Appendix D. Continued.

Prey Availability:
____ diversity of fish species
____ other aquatic prey species (such as crayfish, amphibians, etc.)

____ Total

Other Factors:
____ public ownership
____ private land ownership
____ stream accessibility

____ Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

____ River Rating

Stream Characteristics:
Varying water depths.
One: waters generally too deep and lacked feeding areas
Three: waters that were shallow but had minimal feeding areas
Five: waters with shallow and moderate depths with adequate feeding areas

Slow velocity and low gradient.
One: rivers not highlighted on the selected river reaches map that have fast velocity and high gradient (Figure 2)
Three: rivers not highlighted on the selected river reaches map but were indicated by biologists as rivers with good river otter habitat that have moderate velocity and medium gradient
Five: rivers highlighted on the selected river reaches map that have slow velocity and low gradient

Turbidity (secchi depth).
One: river with the shallowest secchi depth
Two: rivers with secchi depths less than 20 cm
Three: rivers with a secchi depth of 20 cm to 40 cm
Four: rivers with a secchi depth greater than 40 cm
Five: river with the deepest secchi depth

Appendix D. Continued.

Presence of stream meanders near study sites.

One: large rivers (stream order 6 to 7) with no turns or oxbows (½ km upstream and downstream)

Three: small rivers (stream order 3) with 1 to 2 turns

Five: moderate rivers (stream order 4 to 5) with greater than two turns and presence of oxbows

Suitable bank cover.

One: rivers with canopy and graminoid cover less than or equal to 39 percent

Two: rivers with canopy and graminoid cover from 40 to 43 percent

Three: rivers with canopy and graminoid cover from 44 to 48 percent

Four: rivers with canopy and graminoid cover from 49 to 54 percent

Five: rivers with canopy and graminoid cover greater than or equal to 55 percent

Presence of structures, such as logs (along bank and in the stream).

One: rivers with no structures visible at or near (within 100 meters) study sites

Three: rivers with 1 to 2 different structures at or near study sites

Five: rivers with greater than two structures at or near study sites

Permanence of water supply.

One: rivers not highlighted on the selected river reaches map with high potential to dry out during wet to dry periods or freeze solid during winter (Figure 2)

Two: rivers not highlighted on the selected river reaches map which have high potential to dry out during dry periods or freeze solid during winter

Three: rivers highlighted on the selected river reaches map but have moderate potential to dry out during dry periods or freeze solid during winter

Four: rivers highlighted on the selected river reaches map that have minimal potential to dry out during dry periods or freeze solid during winter

Five: rivers highlighted on the selected river reaches map that have no potential to dry out during dry periods or freeze solid during winter

Species diversity (plants and animals).

One: rivers with less than 20 species of plants and animals along study sites

Two: rivers with 20 to 29 species of plants and animals along study sites

Three: rivers with 30 to 39 species of plants and animals along study sites

Four: rivers with 40 to 49 species of plants and animals along study sites

Five: rivers with the greater than or equal to 50 species of plants and animals at study sites

Appendix D. Continued.

Watershed Features:

Presence of wetlands nearby.

One: rivers with no wetlands near (1 km either direction) study sites
Three: rivers with 1 to 2 different wetlands near study sites
Five: rivers with greater than two wetlands near study sites

Presence of beaver populations (dens, scat, chewed woody vegetation).

One: beaver sign observed on 0% of study sites per study river or creek
Two: beaver sign observed on 1 to 25% of study sites per study river or creek
Three: beaver sign observed on 26 to 50% of study sites per study river or creek
Four: beaver sign observed on 51 to 75% of study sites per study river or creek
Five: beaver sign observed on 76 to 100% of study sites per study river or creek

Intensity of beaver trapping according to state and private trappers.

One: rivers with high beaver trapping pressure from state and private entities
Three: rivers with moderate beaver trapping pressure from state and private entities
Five: rivers with low beaver trapping pressure from state and private entities

Human impact on watershed.

One: river with the greatest amount of agriculture, industry, and urban development along the riparian habitat
Two: rivers with prevalence of agriculture, industry, and urban development and severe riparian area destruction
Three: rivers with moderate presence of agriculture, industry, and urban development and moderate riparian area destruction
Four: rivers with low impact from of agriculture, industry, and urban development and low riparian area destruction
Five: rivers with no evidence of agriculture, industry, and urban development and no riparian area destruction

Presence of suitable tributaries.

One: rivers with no large tributaries (orders 3 to 7) found along river
Three: rivers with 1 to14 different large tributraies found along river
Five: rivers with greater than 15 large tributaries found along river

Water Quality:

Nitrogen (nitrate-nitrogen).

One: river with the highest nitrogen level
Two: rivers with nitrogen levels greater than 0.15 mg/l
Three: rivers with nitrogen levels from 0.15 mg/l to 0.1 mg/l
Four: rivers with nitrogen levels less than 0.1 mg/l
Five: river with the lowest nitrogen level

Appendix D. Continued.

Phosphorus (orthophosphate).
One: river with the highest phosphorus level
Two: rivers with phosphorus levels greater than 4 mg/l
Three: rivers with phosphorus levels from 4 mg/l to 2 mg/l
Four: rivers with phosphorus levels less than 2 mg/l
Five: river with the lowest phosphorus level

Alkalinity (methyl-orange).
One: river with the highest alkalinity level
Two: rivers with alkalinity levels greater than 350 mg/l
Three: rivers with alkalinity levels from 350 mg/l to 200 mg/l
Four: rivers with alkalinity levels less than 200 mg/l
Five: river with the lowest alkalinity level

Prey Availability:
Diversity of fish populations.
One: river with the least number of fish species
Two: rivers with less than 10 different fish species
Three: rivers with 10 to 20 different fish species
Four: rivers with greater than 20 different fish species
Five: river with the greatest number of different fish species

Other aquatic prey populations (such as crayfish, amphibians, etc.).
One: rivers with no other aquatic prey species
Three: rivers with 1 to 2 other prey aquatic species found at study sites
Five: rivers with greater than or equal to 3 other aquatic prey species found at study sites

Other Factors:
Public ownership.
One: river with the lowest percent of adjacent lands as public
Two: rivers with less than 20 percent of adjacent lands as public
Three: rivers with from 20 percent to 50 percent of adjacent lands as public
Four: rivers with greater than 50 percent of adjacent lands as public
Five: river with the highest percent of adjacent lands as public

Private land ownership.
One: river with highest percentage of adjacent lands managed as agricultural or grazing lands
Two: rivers with greater than or equal to 90 percent of adjacent lands as agricultural or grazing lands

Appendix D. Continued.

Three: rivers with 89 percent to 65 percent of adjacent lands as agricultural or grazing lands
Four: rivers with less than or equal to 64 percent adjacent lands as agricultural or grazing lands
Five: river with lowest percentage of adjacent agricultural and grazing lands

Stream accessibility.
One: river with no public access areas
Two: rivers with minimal areas as access roads or public access areas and low probability of private landowner consent
Three: rivers with moderate areas as access roads or public access areas and moderate probability of private landowner consent
Four: rivers with adequate areas as access roads or public access areas and high probability of private landowner cooperation
Five: river with substantial amount of public access areas

Appendix E. Vascular plant species (unknowns excluded) found in riparian areas of major rivers in South Dakota.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
Bad	Apocynaceae (Dogbane)	*Apocynum cannabinum,* Indian hemp dogbane
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Artemisia* spp., sagewort
		Aster falcatus, white prairie aster
		Chrysothamnus nauseosus, rubber rabbitbrush
		Cirsium spp., thistle
		Helianthus spp., sunflower
		Ratibida spp., prairie coneflower
		Solidago spp., goldenrod
		Xanthium spp., cocklebur
	Brassicaceae (Mustard)	*Thlaspi* spp., pennycress
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos* spp., snowberry
	Chenopodiaceae (Goosefoot)	*Salsola collina,* tumbleweed
	Convolvulaceae (Morningglory)	*Convolvulus arvensis,* creeping jenny
	Cyperaceae (Sedge)	*Schoenoplectus pungens,* three-square bulrush
		Schoenoplectus tabernaemontani, softstem bulrush
		Schoenoplectus spp., bulrush
	Fabaceae (Bean)	*Amorpha canescens,* leadplant
		Astragalus spp., milkvetch
		Medicago sativa, alfalfa
		Melilotus spp., sweet clover
	Lamiaceae (Mint)	*Stachys palustris,* marsh hedge nettle
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Agropyron cristatum,* crested wheatgrass
		Agropyron smithii, western wheatgrass
		Agrostis stolonifera, redtop
		Alopecurus spp., foxtail
		Bouteloua gracilis, blue grama
		Bromus inermis, smooth brome
		Bromus japonicus, Japanese brome
		Buchloe dactyloides, buffalo grass
		Calamovilfa longifolia, prairie sandweed
		Elymus spp., wildrye
		Elymus trachycaulus, slender wheatrgass
		Elymus villosus, hairy wildrye
		Glyceria spp., mannagrass
		Setaria spp., foxtail
		Spartina pectinata, prairie cordgrass
	Polygonaceae (Buckwheat)	*Rumex crispus,* curly dock

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
	Rosaceae (Rose)	*Prunus virginiana,* choke cherry
		Rosa arkansana, prairie rose
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix spp., willow
	Vitaceae (Grape)	*Vitis riparia,* river-bank grape
Belle Fourche	Aceraceae (Maple)	*Acer negundo,* box elder
	Anacardiaceae (Cashew)	*Rhus aromatica,* skunkbrush
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed
		Artemisia spp., sagewort
		Aster falcatus, white prairie aster
		Grindelia squarrosa, curlycup gumweed
		Helianthus spp., sunflower
		Lactuca oblongifolia, blue lettuce
		Ratibida spp., coneflower
		Solidago spp., goldenrod
		Xanthium spp., cocklebur
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Cyperaceae (Sedge)	*Eleocharis erythropoda,* bald spikerush
		Schoenoplectus pungens, three-squared bulrush
		Schoenoplectus spp., bulrush
	Fabaceae (Bean)	*Amorpha canescens,* leadplant
		Astragalus spp., milkvetch
		Melilotus spp., sweet clover
	Lamiaceae (Mint)	*Salvia* spp., sage
	Oleaceae (Olive)	*Fraxinus* spp., ash
	Poaceae (Grass)	*Agropyron cristatum,* crested wheatgrass
		Agropyron smithii, western wheatgrass
		Bouteloua curtipendula, sideoats
		Bromus spp., brome
		Elymus trachycaulus, slender wheatrgass
		Elymus villosus, hairy wildrye
		Poa pratensis, Kentucky bluegrass
		Spartina pectinata, prairie cordgrass
	Polygonaceae (Buckwheat)	*Rumex crispus,* curly dock
	Rosaceae (Rose)	*Prunus virginiana,* choke cherry
	Scrophulariaceae (Figwort)	*Veronica anagallis-aquatica,* water speedwell
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix spp., willow
	Ulmaceae (Elm)	*Ulmus* spp., elm

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
Big Sioux	Aceraceae (Maple)	*Acer negundo,* box elder
		Acer sacchorinum, maple
	Anacardiaceae (Cashew)	*Rhus* spp., sumac
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed
		Cirsium arvense, Canada thistle
		Cirsium spp., thistle
		Helianthus spp., sunflower
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
		Xanthium spp., cocklebur
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Convolvulaceae (Morningglory)	*Convolvulus arvensis,* creeping jenny
	Cyperaceae (Sedge)	*Carex* spp., sedge
		Schoenoplectus spp., bulrush
	Fagaceae (Oak)	*Quercus* spp., oak
	Grossulariaceae (Currant)	*Ribes* spp., currant
	Lamiaceae (Mint)	*Lycopus asper,* rough bugleweed
		Mentha arvensis, field mint
		Scutellaria galericulata, marsh skullcap
	Onagraceae (Evening Primrose)	*Oenothera* spp., evening primrose
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Beckmannia syzigachne,* American sloughgrass
		Bromus spp., brome
		Elymus villosus, hairy wildrye
		Glyceria spp., mannagrass
		Muhlenbergia spp., muhly
		Phalaris arundinacea, reed canary grass
		Poa compressa, Canada bluegrass
		Sporobolus heterolepis, prairie dropseed
	Polygonaceae (Buckwheat)	*Polygonum coccineum,* marsh smartweed
		Rumex crispus, curly dock
	Rosaceae (Rose)	*Prunus virginiana,* choke cherry
		Rosa arkansana, prairie rose
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix exigua, sandbar willow
	Urticaceae (Nettle)	*Urtica dioica,* stinging nettle
	Verbenaceae (Vervain)	*Verbena hastata,* blue vervain
		Verbena spp., vervain
	Vitaceae (Grape)	*Parthenocissus vitacea,* woodbine

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Vitis riparia, river-bank grape
Cheyenne	Anacardiaceae (Cashew)	*Rhus* spp.
	Apocynaceae (Dogbane)	*Apocynum cannabinum,* Indian hemp dogbane
	Asclepiadaceae (Milkweed)	*Asclepias speciosa,* showy milkweed
		Asclepias spp., milkweed
	Asteraceae (Sunflower)	*Achillea millefolium.,* yarrow
		Ambrosia artemisiifolia, common ragweed
		Ambrosia spp., ragweed
		Artemisia dracunculus, green sagewort
		Artemisia frigida, fringed sagewort
		Artemisia spp., sagewort
		Aster falcatus, white prairie aster
		Helianthus spp., sunflower
		Ratibida spp., prairie coneflower
		Senecio canus, gray ragwort
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
		Xanthium spp., cocklebur
	Cactaceae (Cactus)	*Opuntia* spp., prickly pear
	Cannabaceae (Hemp)	*Humulus lupulus,* common hop
	Convolvulaceae (Morningglory)	*Convolvulus arvensis,* creeping jenny
	Elaeagnaceae (Oleaster)	*Elaeagnus angustifolia,* Russian olive
	Fabaceae (Bean)	*Amorpha canescens,* leadplant
		Astragalus spp., milkvetch
		Dalea purpurea, purple prairie coneflower
		Medicago sativa, alfalfa
		Melilotus spp., sweet clover
		Psoralea spp., scurfpea
	Grossulariaceae (Currant)	*Ribes* spp., currant
	Lamiaceae (Mint)	*Salvia* spp., sage
	Poaceae (Grass)	*Agropyron smithii,* western wheatgrass
		Agropyron spicatum, blue bunch grass
		Alopecurus spp., foxtail
		Bromus ciliatus, fringed brome
		Bromus japonicus, Japanese brome
		Bromus tectorum, downy brome
		Elymus spp., wildrye
		Elymus trachycaulus, slender wheatrgass
		Elymus villosus, hairy wildrye
		Glyceria spp., mannagrass

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Muhlenbergia spp., muhly
		Panicum virgatum, switchgrass
		Sitanion hystrix, squirrel-tail
		Sorghastrum nutans, Indian grass
		Spartina pectinata, prairie cordgrass
	Ranunculaceae (Buttercup)	*Ranunculus* spp., buttercup
	Rosaceae (Rose)	*Rosa arkansana*, prairie rose
	Salicaceae (Willow)	*Populus deltoides*, cottonwood
		Salix spp., willow
	Scrophulariaceae (Figwort)	*Veronica anagallis-aquatica*, water speedwell
	Typhaceae (Cattail)	*Typha* spp., cattail
	Vitaceae (Grape)	*Parthenocissus vitacea*, woodbine
Grand	Aceraceae (Maple)	*Acer negundo*, box elder
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed
		Anemone cylindrica, wind flower
		Artemisia spp., wormwood
		Artemisia frigida, fringed sagewort
		Aster falcatus, white prairie aster
		Conyza canadensis, horseweed
		Grindelia squarrosa, curly cup gumweed
		Helianthus spp., sunflower
		Lactuca oblongifolia, blue lettuce
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
	Brassicaceae (Mustard)	*Barbarea* spp.
	Convolvulaceae (Morningglory)	*Convolvulus arvensis*, creeping jenny
	Cyperaceae (Sedge)	*Carex lanuginosa*, wooly sedge
		Schoenoplectus pungens, three-squared bulrush
		Scirpus pallidus, pale bulrush
		Schoenplectus spp., bulrush
	Cupressaceae (Cypress)	*Juniperus virginiana*, red cedar
	Elaeagnaceae (Oleaster)	*Elaeagnus angustifolia*, Russian olive
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
		Medicago sativa, alfalfa
		Melilotus spp., sweet clover
	Grossulariaceae (Currant)	*Ribes* spp., currant
	Juncaeae (Rush)	*Juncus* spp.
	Lamiaceae (Mint)	*Mentha* spp., mint
	Oleaceae (Olive)	*Fraxinus pennsylvanica*, green ash

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
	Poaceae (Grass)	*Agropyron cristatum,* crested wheatgrass
		Agropyron smithii, western wheatgrass
		Alopecurus spp., foxtail
		Bromus spp., brome
		Elymus trachycaulus, slender wheatrgass
		Elymus villosus, hairy wildrye
		Panicum virgatum, switchgrass
		Poa pratensis, Kentucky bluegrass
		Sitanion hystrix, squirrel-tail
		Spartina pectinata, prairie cordgrass
	Polygonaceae (Buckwheat)	*Rumex crispus,* curly dock
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix spp., willow
	Scrophulariaceae (Figwort)	*Veronica anagallis-aquatica,* water speedwell
James	Aceraceae (Maple)	*Acer negundo,* box elder
	Anacardiaceae (Cashew)	*Rhus glaber,* sumac
		Toxicodendron rydbergii, poison ivy
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Cirsium arvense,* Canada thistle
		Xanthium spp., cocklebur
		Solidago spp., goldenrod
		Artemisia spp., sagewort
		Helianthus spp., sunflower
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Cornaceae (Dogwood)	*Cornus* spp., dogwood
	Elaeagnaceae (Oleaster)	*Elaeagnus angustifolia,* Russian olive
	Equisetaceae (Horsetail)	*Equisetum* spp., horsetail
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
	Grossulariaceae (Currant)	*Ribes americanum,* black currant
		Ribes spp., currant
	Lamiaceae (Mint)	*Agastache foeniculum,* lavender hyssop
		Lycopus asper, rough bugleweed
		Mentha arvensis, field mint
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Agropyron smithii,* western wheatgrass
		Alopecurus spp., foxtail
		Bromus inermis, smooth brome
		Bromus spp., brome
		Elymus trachycaulus, slender wheatrgass
		Poa compressa, Canada bluegrass

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Poa pratensis, Kentucky bluegrass
		Spartina pectinata, prairie cordgrass
	Polygonaceae (Buckwheat)	*Rumex crispus*, curly dock
	Ranunculaceae (Buttercup)	*Aquilegia canadensis*, wild columbine
		Ranunculus spp., buttercup
	Rosaceae (Rose)	*Amelanchier* spp., serviceberry
		Prunus virginiana, choke cherry
		Prunus americana, wild plum
		Rosa arkansana, prairie rose
	Salicaceae (Willow)	*Populus deltoides*, cottonwood
		Salix spp., willow
	Ulmaceae (Elm)	*Ulmus* spp., elm
	Vitaceae (Grape)	*Vitis riparia*, river-bank grape
Jorgenson	Aceraceae (Maple)	*Acer negundo*, box elder
	Anacardiaceae (Cashew)	*Rhus glaber*, sumac
		Toxicodendron spp., poison ivy
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Erigeron* spp., fleabane
		Helianthus spp., sunflower
		Ratibida spp., prairie coneflower
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
		Xanthium spp., cocklebur
	Betulaceae (Birch)	*Betula papyrifera*, paper birch
	Convolvulaceae (Morningglory)	*Convolvulus arvensis*, creeping jenny
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
		Melilotus spp., sweet clover
	Grossulariaceae (Currant)	*Ribes* spp., currant
	Lamiaceae (Mint)	*Mentha arvensis*, mint
		Salvia spp., sage
	Poaceae (Grass)	*Bromus* spp., brome
		Poa compressa, Canada bluegrass
	Ulmaceae (Elm)	*Ulmus* spp., elm
	Vitaceae (Grape)	*Vitis riparia*, river-bank grape
Little Minnesota	Aceraceae (Maple)	*Acer negundo*, box elder
	Anacardiaceae (Cashew)	*Toxicodendron rydbergii*, poison ivy
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Cirsium arvense*, Canada thistle
		Solidago spp., goldenrod
		Helianthus spp., sunflower

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
	Betulaceae (Birch)	*Betula papyrifera,* paper birch
	Caprifoliaceae (Honeysuckle)	*Lonicera dioica,* honeysuckle
		Symphoricarpos occidentalis, snowberry
	Cyperaceae (Sedge)	*Schoenoplectuss* spp., bulrush
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
		Desmodium canadense, Canada tickclover
		Medicago sativa, alfalfa
		Melilotus spp., sweet clover
	Grossulariaceae (Currant)	*Ribes* spp., currant
	Lamiaceae (Mint)	*Salvia* spp., sage
		Mentha arvensis, mint
	Poaceae (Grass)	*Bromus* spp., brome
		Poa pratensis, Kentucky bluegrass
	Rosaceae (Rose)	*Amelanchier* spp., serviceberry
	Scrophulariaceae (Figwort)	*Verbascum thapsus,* mullein
	Ulmaceae (Elm)	*Ulmus* spp., elm
	Vitaceae (Grape)	*Parthenocissus vitacea,* woodbine
		Vitis riparia, river-bank grape
Little White	Asteraceae (Sunflower)	*Artemisia* spp., sagewort
		Helianthus spp., sunflower
		Lactuca oblongifolia, blue lettuce
		Solidago spp., goldenrod
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Cupressaceae (Cypress)	*Juniperus virginiana,* red cedar
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
		Melilotus spp., sweet clover
	Fagaceae (Oak)	*Quercus macrocarpa,* bur oak
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Agropyron* spp.
		Calamovilfa longifolia, prairie sandweed
		Elymus villosus, hairy wildrye
		Panicum virgatum, switchgrass
		Poa pratensis, Kentucky bluegrass
		Spartina pectinata, prairie cordgrass
	Rosaceae (Rose)	*Prunus virginiana,* choke cherry
	Salicaceae (Willow)	*Salix* spp., willow
	Ulmaceae (Elm)	*Ulmus* spp., elm
	Verbenaceae (Verbena)	*Verbena stricta,* wooly vervain
	Vitaceae (Grape)	*Parthenocissus vitacea,* woodbine
		Vitis riparia, river-bank grape

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
Medicine Creek	Anacardiaceae (Cashew)	*Rhus* spp.
		Toxicodendron rydbergii, poison ivy
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed
		Aster falcatus, white prairie aster
		Helianthus spp., sunflower
		Lactuca oblongifolia, blue lettuce
		Solidago spp., goldenrod
	Cannabaceae (Hemp)	*Humulus lupulus,* common hop
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Convolvulaceae (Morningglory)	*Convolvulus arvensis,* creeping jenny
	Cyperaceae (Sedge)	*Scirpus pallidus,* pale bulrush
	Elaeagnaceae (Oleaster)	*Elaeagnus angustifolia,* Russian olive
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
	Lamiaceae (Mint)	*Dracocephalum parviflorum,* American dragonhead
		Salvia spp., sage
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Agropyron cristatum,* crested wheatgrass
		Agropyron smithii, western wheatgrass
		Alopecurus spp., foxtail
		Bromus inermis, smooth brome
		Bromus japonicus, Japanese brome
		Elymus trachycaulus, slender wheatrgass
		Elymus villosus, hairy wildrye
		Poa compressa, Canada bluegrass
		Poa pratensis, Kentucky bluegrass
	Polygonaceae (Buckwheat)	*Polygonum coccineum,* marsh smartweed
		Rumex crispus, curly dock
	Rosaceae (Rose)	*Prunus virginiana,* choke cherry
		Rosa arkansana, prairie rose
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix spp., willow
	Typhaceae (Cattail)	*Typha* spp., cattail
Missouri	Aceraceae (Maple)	*Acer negundo,* box elder
	Anacardiaceae (Cashew)	*Rhus glaber,* sumac
		Toxicodendron rydbergii, poison ivy
	Apiaceae (Carrot)	*Cicuta* spp., water hemlock
	Apocynaceae (Dogbane)	*Apocynum cannabinum,* Indian hemp dogbane
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Aster falcatus, white prairie aster
		Cirsium spp., thistle
		Conyza canadensis, horseweed
		Helianthus spp., sunflower
		Lactuca oblongifolia, blue lettuce
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
		Xanthium spp., cocklebur
	Convolvulaceae (Morningglory)	*Convolvulus arvensis,* creeping jenny
	Cyperaceae (Sedge)	*Schoenoplectus* spp., bulrush
	Cupressaceae (Cypress)	*Juniperus virginiana,* red cedar
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
		Medicago sativa, alfalfa
		Melilotus spp., sweet clover
	Fagaceae (Oak)	*Quercus* spp., oak
	Lamiaceae (Mint)	*Lycopus* spp., bugleweed
		Mentha arvensis, field mint
		Nepeta cataria, catnip
		Scutellaria galericulata, marsh skullcap
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Onagraceae (Evening Primrose)	*Gaura coccinea,* gaura
	Poaceae (Grass)	*Bouteloua curtipendula,* sideoats
		Bromus spp., brome
		Elymus villosus, hairy wildrye
		Glyceria spp., mannagrass
		Panicum virgatum, switchgrass
		Poa pratensis, Kentucky bluegrass
	Polygonaceae (Buckwheat)	*Polygonum coccineum,* marsh smartweed
		Rumex crispus, curly dock
	Ranunculaceae (Buttercup)	*Ranunculus* spp., buttercup
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix spp., willow
	Typhaceae (Cattail)	*Typha* spp., cattail
	Ulmaceae (Elm)	*Ulmus* spp., elm
	Verbenaceae (Vervain)	*Verbena* spp., vervain
	Vitaceae (Grape)	*Parthenocissus vitacea,* woodbine
		Vitis riparia, river-bank grape
Moreau	Asteraceae (Sunflower)	*Ambrosia artemisiifolia,* common ragweed
		Ambrosia spp., ragweed
		Artemisia spp., sagewort

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Aster falcatus, white prairie aster
		Helianthus spp., sunflower
		Rudbeckia spp., coneflower
		Solidago spp., goldenrod
		Xanthium spp., cocklebur
	Caesalpiniaceae (Caesalpinia)	*Gleditsia triacanthos,* honey locust
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Convolvulaceae (Morningglory)	*Convolvulus arvensis,* creeping jenny
	Cyperaceae (Sedge)	*Carex* spp., sedge
		Schoenoplectus spp., bulrush
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
	Poaceae (Grass)	*Agropyron smithii,* western wheatgrass
		Agrostis stolonifera, redtop
		Bouteloua curtipendula, sideoats
		Bouteloua gracilis, blue grama
		Calamovilfa longifolia, prairie sandweed
		*Cenchrus longispinus,*sandbar
		Elymus villosus, hairy wildrye
		Muhlenbergia spp., (green) muhly
		Poa pratensis, Kentucky bluegrass
		Spartina pectinata, prairie cordgrass
	Polygonaceae (Buckwheat)	*Rumex acetosella,* sheep sorrel
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix spp., willow
N. Fork Whetstone	Aceraceae (Maple)	*Acer negundo,* box elder
	Apiaceae (Carrot)	*Daucus carota,* carrot
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed
		Cirsium spp., thistle
		Helianthus spp., sunflower
		Matricaria matricarioides, pinneapple weed
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
		Xanthium spp., cocklebur
	Cannabaceae (Hemp)	*Humulus lupulus,* common hop
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Cucurbitaceae (Stickleaf)	*Echinocystis lobata,* wild cucumber
	Cyperaceae (Sedge)	*Carex vulpinoidea,* fox sedge
	Equisetaceae (Horsetail)	*Equisetum* spp., horsetail
	Fabaceae (Bean)	*Medicago sativa,* alfalfa

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Melilotus spp., sweet clover
	Fagaceae (Oak)	*Quercus macrocarpa,* oak
	Grossulariaceae (Currant)	*Ribes* spp., currant
	Lamiaceae (Mint)	*Lycopus* spp., bugleweed
		Mentha arvensis, field mint
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Bromus* spp., brome
		Poa compressa, Canada bluegrass
		Setaria spp., foxtail
	Verbenaceae (Vervain)	*Verbena* spp., vervain
	Vitaceae (Grape)	*Parthenocissus vitacea,* woodbine
		Vitis riparia, river-bank grape
Rapid Creek	Aceraceae (Maple)	*Acer negundo,* box elder
	Anacardiaceae (Cashew)	*Toxicodendron rydbergii,* poison ivy
	Asteraceae (Sunflower)	*Artemisia* spp., sagewort
		Cirsium arvense, Canada thistle
		Gutierrezia sarothrae, snakeweed
		Helianthus spp., sunflower
		Solidago spp., goldenrod
		Xanthium spp., cocklebur
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
		Melilotus spp., sweet clover
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Bromus inermis,* smooth brome
		Bromus spp., brome
		Elymus villosus, hairy wildrye
		Panicum virgatum, switchgrass
		Poa pratensis, Kentucky bluegrass
		Spartina pectinata, prairie cordgrass
	Polygonaceae (Buckwheat)	*Rumex crispus,* curly dock
	Rosaceae (Rose)	*Rosa* spp.
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
		Salix spp., willow
	Ulmaceae (Elm)	*Ulmus* spp., elm
	Vitaceae (Grape)	*Vitis riparia,* river-bank grape
Vermillion	Aceraceae (Maple)	*Acer negundo,* box elder
		Acer saccharium, maple
	Apiaceae (Carrot)	*Heracleum sphondylium,* cowparsnip

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Osmorhiza longistylis, longstyle sweetroot
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed
		Cirsium spp., thistle
		Erigeron spp., fleabane
		Helianthus spp., sunflower
		Lactuca oblongifolia, blue lettuce
		Petasites spp., (arrowleaf) coltsfoot
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
		Xanthium spp., cocklebur
	Cannabaceae (Hemp)	*Humulus lupulus,* common hop
	Elaeagnaceae (Oleaster)	*Shepherdia argentea,* buffalo berry
	Fabaceae (Bean)	*Melilotus* spp., sweet clover
	Fagaceae (Oak)	*Quercus macrocarpa,* oak
	Fumariaceae (Fumitory)	*Corydalis aurea,* golden corydalis
	Lamiaceae (Mint)	*Mentha spp.,* mint
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Bromus* spp., brome
		Catabrosa aquatica, brook grass
		Elymus spp., wildrye
		Elymus villosus, hairy wildrye
		Poa compressa, Canada bluegrass
		Poa pratensis, Kentucky bluegrass
	Ranunculaceae (Buttercup)	*Clematis ligusticifolia,* virgin's bower
		Ranunculus spp., buttercup
	Rosaceae (Rose)	*Crataegus* spp., hawthorne
		Prunus virginiana, choke cherry
		Rubus spp., raspberry
	Salicaceae (Willow)	*Populus deltoides,* cottonwood
	Ulmaceae (Elm)	*Ulmus* spp., elm
	Vitaceae (Grape)	*Vitis riparia,* river-bank grape
Virgin Creek	Apocynaceae (Dogbane)	*Apocynium cannabinum,* Indian hemp dogbane
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Cirsium* spp., thistle
		Helianthus spp., sunflower
		Solidago spp., goldenrod
		Taraxacum spp., dandelion
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Cucurbitaceae (Stickleaf)	*Echinocystis lobata,* wild cucumber
	Cyperaceae (Sedge)	*Carex lanuginosa,* wooly sedge

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
	Fabaceae (Bean)	*Astragalus spp.,* milkvetch
	Lamiaceae (Mint)	*Mentha spp.*, mint
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Bromus* spp., brome
	Rosaceae (Rose)	*Prunus virginiana,* choke cherry
		Rosa spp.
	Saliaceae (Willow)	*Salix* spp., willow
	Ulmaceae (Elm)	*Ulmus* spp., elm
White	Anacardiaceae (Cashew)	*Rhus aromatic,* skunkbrush
		Rhus spp.
	Apiaceae (Carrot)	*Sanicula* spp., snakeroot
	Apocynaceae (Dogbane)	*Apocynum cannabinum,* Indian hemp dogbane
	Asclepiadaceae (Milkweed)	*Asclepias* spp., milkweed
	Asteraceae (Sunflower)	*Ambrosia* spp., ragweed
		Aster falcatus, white prairie aster
		Erigeron strigosus, daisy fleabane
		Helianthus spp., sunflower
		Matricaria matricarioides, pinneapple weed
		Ratibida spp., prairie coneflower
		Solidago spp., goldenrod
		Tanacetum vulgare, common tansy
		Taraxacum spp., dandelion
		Xanthium spp., cocklebur
	Caprifoliaceae (Honeysuckle)	*Symphoricarpos occidentalis,* snowberry
	Cyperaceae (Sedge)	*Carex lanuginosa,* wooly sedge
		Carex spp., sedge
		Schoenoplectus pungens, three-square bulrush
	Cupressaceae (Cypress)	*Juniperus virginiana,* red cedar
	Elaeagnaceae (Oleaster)	*Elaeagnus angustifolia,* Russian olive
	Equisetaceae (Horsetail)	*Equisetum* spp., horsetail
	Fabaceae (Bean)	*Astragalus* spp., milkvetch
		Medicago sativa, alfalfa
		Melilotus spp., sweet clover
	Grossulariaceae (Currant)	*Ribes* spp., currant
	Oleaceae (Olive)	*Fraxinus pennsylvanica,* green ash
	Poaceae (Grass)	*Agropyron smithii,* western wheatgrass
		Agrostis stolonifera, redtop
		Bromus japonicus, Japanese brome
		Bromus spp., brome
		Calamovilfa longifolia, prairie sandweed

Appendix E. Continued.

RIVER/CREEK	FAMILY	SCIENTIFIC NAME, COMMON NAME
		Cenchrus longispinus, sandbar
		Elymus trachycaulus, slender wheatrgass
		Elymus villosus, hairy wildrye
		Muhlenbergia spp., muhly
		Panicum virgatum, switchgrass
		Phleum pratense, timothy
		Poa pratensis, Kentucky bluegrass
		Sitanion hystrix, squirrel-tail
		Spartina pectinata, prairie cordgrass
	Rosaceae (Rose)	*Prunus virginiana*, choke cherry
		Rosa americana, wild plum
	Rubiaceae (Madder)	*Galium boreale*, northern bedstraw
	Salicaceae (Willow)	*Populus deltoides*, cottonwood
		Salix spp., willow
	Typhaceae (Cattail)	*Typha* spp., cattail
	Verbenaceae (Verbena)	*Verbena stricta*, wooly vervain
	Vitaceae (Grape)	*Parthenocissus vitacea*, woodbine
		Vitis riparia, river-bank grape

Appendix F. Prey species, besides fish, available along major rivers in South Dakota.

River/Creek	Family	Scientific Name, Common Name
Bad	Bufonidae (True Toads)	*Bufo* spp., true toads
	Ranidae (True Frogs)	*Rana pipiens*, northern leopard frog
		Rana spp., true frogs
	Viperidae (Pit Vipers)	*Crotalus viridis*, prairie rattlesnake
Belle Fourche	Ranidae (True Frogs)	*Rana* spp., true frogs
Big Sioux	Anodontidae (Mussels)	
	Ranidae (True Frogs)	*Rana* spp., true frogs
Grand	Ranidae (True Frogs)	*Rana pipiens*, northern leopard frog
James	Anodontidae (Mussels)	
	Ranidae (True Frogs)	*Rana pipiens*, northern leopard frog
Jorgenson	Ranidae (True Frogs)	*Rana* spp., true frogs
Little Minnesota	Anodontidae (Mussels)	
	Ranidae (True Frogs)	*Rana pipiens*, northern leopard frog
Medicine Creek	Cambaridae (Crayfish)	*Orconectus virilis*, northern crayfish
	Ranidae (True Frogs)	*Rana pipiens*, northern leopard frog
		Rana spp., true frogs
Moreau	Ranidae (True Frogs)	*Rana spp.*, true frogs
Vermillion	Anodontidae (Mussels)	
	Colubridae (Colubrids)	*Thamnophis sirtalis*, common garter snake
	Ranidae (True Frogs)	*Rana* spp., true frogs
Virgin Creek	Anodontidae (Mussels)	
	Ranidae (True Frogs)	*Rana* spp., true frogs

Appendix G. Completed river rating forms for each study river/creek in South Dakota.

River Rating Form

Stream/River/Wetland Name: Bad River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
4	turbidity (secchi depth)
5	presence of stream meanders
3	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
4	species diversity (plants and animals)
32	Total

Watershed Features:

1	presence of wetlands nearby
3	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
4	human impact on watershed
3	presence of suitable tributaries
14	Total

Water Quality:

3	nitrogen
4	phosphorus
4	alkalinity
11	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
5 other aquatic prey species (such as crayfish, amphibians, etc.)

8 Total

Other Factors:

2 public ownership
4 private land ownership
4 stream accessibility

10 Total

River Rating = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

75 River Rating (Bad River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Belle Fourche River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
4	turbidity (secchi depth)
5	presence of stream meanders
2	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
3	species diversity (plants and animals)
30	Total

Watershed Features:

1	presence of wetlands nearby
3	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
2	human impact on watershed
3	presence of suitable tributaries
12	Total

Water Quality:

4	nitrogen
4	phosphorus
4	alkalinity
12	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

6 Total

Other Factors:

2 public ownership
3 private land ownership
2 stream accessibility

7 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

67 River Rating (Belle Fourche River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Big Sioux River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
3	turbidity (secchi depth)
5	presence of stream meanders
5	suitable bank cover
5	presence of structures (along bank & in the stream)
3	permanence of water supply
4	species diversity (plants and animals)
35	Total

Watershed Features:

3	presence of wetlands nearby
4	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
2	human impact on watershed
3	presence of suitable tributaries
15	Total

Water Quality:

2	nitrogen
3	phosphorus
3	alkalinity
8	Total

Appendix G. Continued.

Prey Availability:

4 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

7 Total

Other Factors:

2 public ownership
3 private land ownership
4 stream accessibility

9 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

74 River Rating (Big Sioux River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Cheyenne River.

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
3	turbidity (secchi depth)
5	presence of stream meanders
3	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
4	species diversity (plants and animals)
31	Total

Watershed Features:

1	presence of wetlands nearby
4	presence of beaver populations (dens, scat, chewed woody vegetation)
1	intensity of beaver trapping
3	human impact on watershed
5	presence of suitable tributaries
14	Total

Water Quality:

4	nitrogen
2	phosphorus
4	alkalinity
10	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
1 other aquatic prey species (such as crayfish, amphibians, etc.)

4 Total

Other Factors:

3 public ownership
4 private land ownership
2 stream accessibility

9 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

68 River Rating (Cheyenne River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Grand River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
5	turbidity (secchi depth)
5	presence of stream meanders
1	suitable bank cover
1	presence of structures (along bank & in the stream)
3	permanence of water supply
4	species diversity (plants and animals)
29	Total

Watershed Features:

1	presence of wetlands nearby
1	presence of beaver populations (dens, scat, chewed woody vegetation)
5	intensity of beaver trapping
3	human impact on watershed
3	presence of suitable tributaries
13	Total

Water Quality:

4	nitrogen
4	phosphorus
3	alkalinity
11	Total

Appendix G. Continued.

Prey Availability:

4 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

7 Total

Other Factors:

1 public ownership
3 private land ownership
1 stream accessibility

5 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

65 River Rating (Grand River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: James River.

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
3	turbidity (secchi depth)
5	presence of stream meanders
4	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
4	species diversity (plants and animals)
32	Total

Watershed Features:

3	presence of wetlands nearby
5	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
2	human impact on watershed
3	presence of suitable tributaries
16	Total

Water Quality:

4	nitrogen
1	phosphorus
3	alkalinity
8	Total

Appendix G. Continued.

Prey Availability:

5 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

8 Total

Other Factors:

2 public ownership
2 private land ownership
4 stream accessibility

8 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

72 River Rating (James River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Jorgenson River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

3	varying water depths
5	slow velocity and low gradient
3	turbidity (secchi depth)
3	presence of stream meanders
5	suitable bank cover
3	presence of structures (along bank & in the stream)
2	permanence of water supply
2	species diversity (plants and animals)
26	Total

Watershed Features:

5	presence of wetlands nearby
5	presence of beaver populations (dens, scat, chewed woody vegetation)
5	intensity of beaver trapping
3	human impact on watershed
1	presence of suitable tributaries
19	Total

Water Quality:

4	nitrogen
3	phosphorus
3	alkalinity
10	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

6 Total

Other Factors:

2 public ownership
3 private land ownership
2 stream accessibility

7 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

68 River Rating (Jorgenson River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Little Minnesota .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

3	varying water depths
5	slow velocity and low gradient
4	turbidity (secchi depth)
3	presence of stream meanders
2	suitable bank cover
3	presence of structures (along bank & in the stream)
2	permanence of water supply
2	species diversity (plants and animals)
24	Total

Watershed Features:

5	presence of wetlands nearby
1	presence of beaver populations (dens, scat, chewed woody vegetation)
5	intensity of beaver trapping
3	human impact on watershed
1	presence of suitable tributaries
15	Total

Water Quality:

3	nitrogen
4	phosphorus
3	alkalinity
10	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

6 Total

Other Factors:

2 public ownership
3 private land ownership
2 stream accessibility

7 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

62 River Rating (Little Minnesota River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Little White River.

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
2	turbidity (secchi depth)
5	presence of stream meanders
3	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
2	species diversity (plants and animals)
28	Total

Watershed Features:

3	presence of wetlands nearby
5	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
4	human impact on watershed
3	presence of suitable tributaries
18	Total

Water Quality:

4	nitrogen
3	phosphorus
3	alkalinity
10	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
1 other aquatic prey species (such as crayfish, amphibians, etc.)

4 Total

Other Factors:

2 public ownership
4 private land ownership
3 stream accessibility

9 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

69 River Rating (Little White River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Medicine Creek.

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

3	varying water depths
5	slow velocity and low gradient
3	turbidity (secchi depth)
3	presence of stream meanders
3	suitable bank cover
3	presence of structures (along bank & in the stream)
2	permanence of water supply
3	species diversity (plants and animals)
25	Total

Watershed Features:

1	presence of wetlands nearby
3	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
3	human impact on watershed
1	presence of suitable tributaries
11	Total

Water Quality:

4	nitrogen
3	phosphorus
3	alkalinity
10	Total

Appendix G. Continued.

Prey Availability:

4 diversity of fish species
5 other aquatic prey species (such as crayfish, amphibians, etc.)

9 Total

Other Factors:

2 public ownership
4 private land ownership
3 stream accessibility

9 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

64 River Rating (Medicine Creek)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Missouri River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

1	varying water depths
5	slow velocity and low gradient
5	turbidity (secchi depth)
1	presence of stream meanders
4	suitable bank cover
3	presence of structures (along bank & in the stream)
5	permanence of water supply
4	species diversity (plants and animals)
28	Total

Watershed Features:

3	presence of wetlands nearby
3	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
2	human impact on watershed
5	presence of suitable tributaries
16	Total

Water Quality:

3	nitrogen
4	phosphorus
3	alkalinity
10	Total

Appendix G. Continued.

Prey Availability:

4 diversity of fish species
1 other aquatic prey species (such as crayfish, amphibians, etc.)

5 Total

Other Factors:

5 public ownership
4 private land ownership
5 stream accessibility

14 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

73 River Rating (Missouri River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Moreau River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
1	turbidity (secchi depth)
5	presence of stream meanders
2	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
2	species diversity (plants and animals)
26	Total

Watershed Features:

1	presence of wetlands nearby
5	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
3	human impact on watershed
3	presence of suitable tributaries
15	Total

Water Quality:

5	nitrogen
3	phosphorus
3	alkalinity
11	Total

Appendix G. Continued.

Prey Availability:

4 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

7 Total

Other Factors:

2 public ownership
3 private land ownership
3 stream accessibility

8 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

67 River Rating (Moreau River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: North Fork of the Whetstone River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
4	turbidity (secchi depth)
3	presence of stream meanders
3	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
2	species diversity (plants and animals)
28	Total

Watershed Features:

5	presence of wetlands nearby
5	presence of beaver populations (dens, scat, chewed woody vegetation)
5	intensity of beaver trapping
3	human impact on watershed
1	presence of suitable tributaries
19	Total

Water Quality:

4	nitrogen
4	phosphorus
3	alkalinity
11	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
1 other aquatic prey species (such as crayfish, amphibians, etc.)

4 Total

Other Factors:

3 public ownership
4 private land ownership
3 stream accessibility

10 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

72 River Rating (North Fork of the Whetstone River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Rapid Creek .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

3	varying water depths
5	slow velocity and low gradient
5	turbidity (secchi depth)
3	presence of stream meanders
3	suitable bank cover
1	presence of structures (along bank & in the stream)
3	permanence of water supply
3	species diversity (plants and animals)
26	Total

Watershed Features:

1	presence of wetlands nearby
5	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
3	human impact on watershed
1	presence of suitable tributaries
13	Total

Water Quality:

1	nitrogen
3	phosphorus
3	alkalinity
7	Total

Appendix G. Continued.

Prey Availability:

3 diversity of fish species
1 other aquatic prey species (such as crayfish, amphibians, etc.)

4 Total

Other Factors:

3 public ownership
4 private land ownership
4 stream accessibility

11 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

61 River Rating (Rapid Creek)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Vermillion River.

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
3	turbidity (secchi depth)
3	presence of stream meanders
4	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
3	species diversity (plants and animals)
29	Total

Watershed Features:

3	presence of wetlands nearby
3	presence of beaver populations (dens, scat, chewed woody vegetation)
3	intensity of beaver trapping
2	human impact on watershed
3	presence of suitable tributaries
14	Total

Water Quality:

4	nitrogen
3	phosphorus
3	alkalinity
10	Total

Appendix G. Continued.

Prey Availability:

4 diversity of fish species
5 other aquatic prey species (such as crayfish, amphibians, etc.)

9 Total

Other Factors:

2 public ownership
2 private land ownership
2 stream accessibility

6 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

68 River Rating (Vermillion River)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: Virgin Creek .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

3	varying water depths
5	slow velocity and low gradient
2	turbidity (secchi depth)
3	presence of stream meanders
1	suitable bank cover
3	presence of structures (along bank & in the stream)
2	permanence of water supply
1	species diversity (plants and animals)
20	Total

Watershed Features:

1	presence of wetlands nearby
5	presence of beaver populations (dens, scat, chewed woody vegetation)
5	intensity of beaver trapping
4	human impact on watershed
1	presence of suitable tributaries
16	Total

Water Quality:

3	nitrogen
4	phosphorus
4	alkalinity
11	Total

Appendix G. Continued.

Prey Availability:

4 diversity of fish species
3 other aquatic prey species (such as crayfish, amphibians, etc.)

7 Total

Other Factors:

3 public ownership
3 private land ownership
3 stream accessibility

9 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

63 River Rating (Virgin Creek)

Appendix G. Continued.

River Rating Form

Stream/River/Wetland Name: White River .

Explanation of Evaluation:
Evaluated each characteristic using the designated range from 1-5, where higher values indicated higher river otter suitability. Rates were based on data collected and available.

Stream Characteristics:

5	varying water depths
5	slow velocity and low gradient
2	turbidity (secchi depth)
5	presence of stream meanders
3	suitable bank cover
3	presence of structures (along bank & in the stream)
3	permanence of water supply
5	species diversity (plants and animals)
31	Total

Watershed Features:

1	presence of wetlands nearby
3	presence of beaver populations (dens, scat, chewed woody vegetation)
1	intensity of beaver trapping
3	human impact on watershed
3	presence of suitable tributaries
11	Total

Water Quality:

2	nitrogen
3	phosphorus
1	alkalinity
6	Total

Appendix G. Continued.

Prey Availability:

2 diversity of fish species
1 other aquatic prey species (such as crayfish, amphibians, etc.)

3 Total

Other Factors:

2 public ownership
4 private land ownership
3 stream accessibility

9 Total

River Rating Total = Stream Characteristics + Watershed Features + Water Quality + Prey Availability + Logistical Factors

60 River Rating (White River)