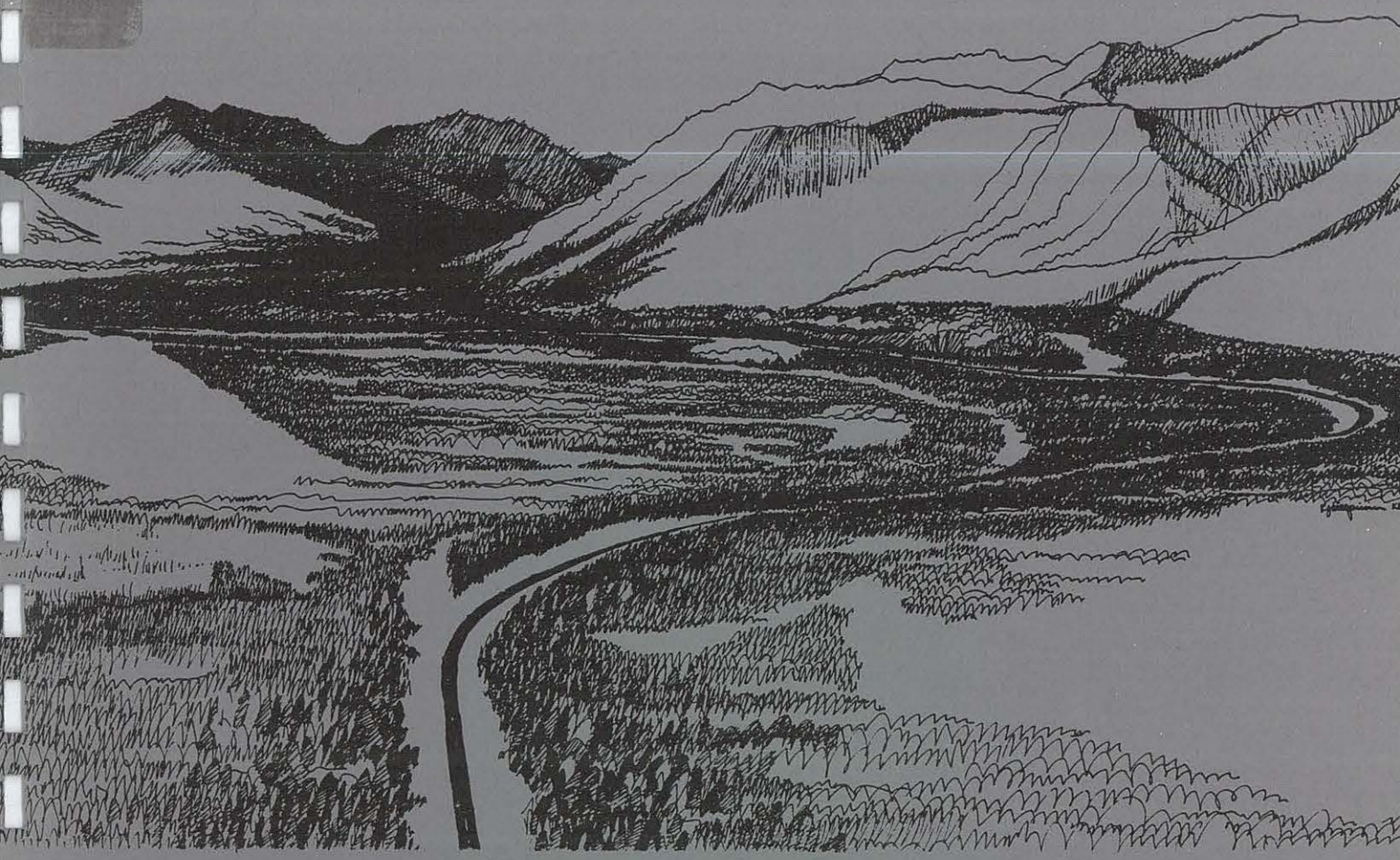

IDENTIFYING WILDLIFE LANDS : FISH AND WILDLIFE ANALYSIS FOR THE SUSITNA RIVER BASIN STUDY

Final Report

by
U.S. Department of Agriculture

in cooperation with
State of Alaska and the
U.S. Fish and Wildlife Service

October 1985

Final Report

Identifying Wildlife Lands: Fish and Wildlife Analysis for the Susitna River Basin Study

Prepared by

United States Department of Agriculture

Soil Conservation Service

Forest Service

In Cooperation with

State of Alaska

and

United States Fish and Wildlife Service

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Introduction

The following report covers fish and wildlife studies conducted in the Susitna River Basin as part of the Susitna Cooperative River Basin Study. The report is divided into five parts:

Part I, Background, discusses both the origins of the Susitna Cooperative River Basin Study and the basis for Soil Conservation Service participation in Basin fish and wildlife analyses.

Part II, The Study Area, describes very briefly the location of the Susitna River Basin and the four "subbasins" into which it was divided for study purposes.

Part III, Fish and Wildlife Resources in the Susitna River Basin, provides a general description of the fish and wildlife species and habitats currently found in the Basin. Current human uses of these resources, and changes affecting their future use and availability, are also briefly discussed.

Part IV, Fish and Wildlife Modeling and Mapping in the Susitna River Basin, describes the technical fish and wildlife analyses conducted by the SCS as part of the River Basin Study. These analyses consisted of two main activities: 1) working with the USFWS and the ADF&G to develop ways to use River Basin data in "modeling" the relative fish and wildlife values of Basin lands, and 2) assisting the ADF&G in developing procedures for

creating fish and wildlife "element maps," that is, maps showing Basin lands best suited for maintaining desired fish and wildlife resources. Use of these products by land use planners is also briefly discussed.

Part V, Fish and Wildlife Field Investigations, briefly identifies wildlife-related data collected by the SCS and FS in the field during the Cooperative Study.

Appendixes supplement the information provided in these five parts.

I. Background

In recent years, the State of Alaska and the Matanuska-Susitna Borough have been determining which of their lands should be retained in public ownership and which should be sold or leased to the private sector. These determinations have generally been based on what the State or Borough has perceived to be the "best uses" for particular parcels. Historically, "best uses" have usually been identified with very little information because adequate inventory data were not available. As a result, Basin lands have often been either inappropriately developed, e.g., homes have been built in flood plains, septic systems in or adjacent to wetlands; or lands have been used in ways that have not served the public interest, e.g., public trails or hunting areas have been sold to private interests who then blocked public access. Environmental problems, damage to structures, and conflicts among land users have inevitably resulted. Finding solutions to these problems has been difficult in the absence of adequate data, and because opinions often differ on what constitutes a parcel's best use or the public's best interest.

In order to develop a data base on which alternative land uses could be logically evaluated and selected, the Alaska Department of Natural Resources (ADNR) requested technical assistance from the U.S. Department of Agriculture-Soil Conservation Service in February 1976. In response, the USDA, in June 1976, authorized the Alaskan River Basin Study under Public Law 83-566. In February 1978, a plan of work for the Alaska Rivers-Susitna

River Basin Study was adopted. For study purposes, the Susitna Basin was divided into four subbasins: Willow, Talkeetna, Beluga, and Upper Susitna (Figure 1). The Willow Subbasin Study was scheduled first. Once it was completed (USDA 1981c), a joint study of the Talkeetna, Beluga, and Upper Susitna Subbasins was undertaken.

Public Law 83-566 (Watershed Protection and Flood Prevention Act of 1954) provides broad authority for cooperation between USDA agencies and other Federal and State agencies in river basin planning, surveys, and investigations. The Soil Conservation Service (SCS) directs these activities, working closely with the USDA Forest Service (FS) and Economic Research Service (ERS). Conducted at the request of cooperating agencies, in this case the Alaska Department of Natural Resources, river basin studies and investigations:

- identify water and land resource problems,

- analyze the economic base and environmental setting, and

- suggest alternative plans for solving identified problems and improving the economy and environment.

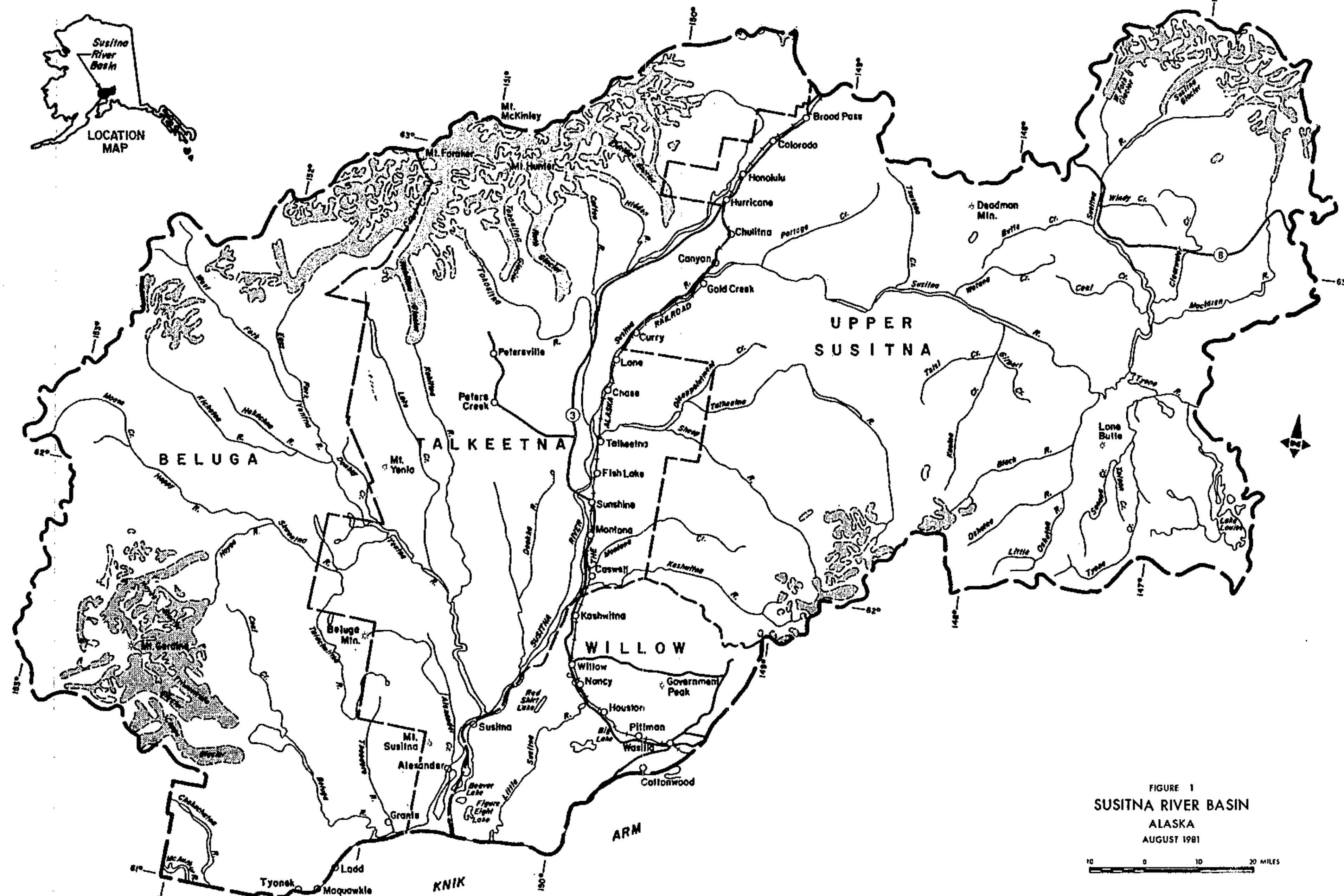


FIGURE 1
SUSITNA RIVER BASIN
ALASKA
AUGUST 1981

10 0 10 20 MILES

Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:1,000,000 Nat. Atlas.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-N-24165

USDA involvement in river basin fish and wildlife investigations is predicated on Department policy as outlined in Memoranda from the Secretary of Agriculture. Current USDA fish and wildlife policy, articulated in Secretary's Memo 9500-4, is to "... assure that the values of fish and wildlife are recognized, and that their habitats, both terrestrial and aquatic, including wetlands, are recognized and enhanced, where possible, as the Department carries out its overall missions." Within its authorities, Department activities in support of this policy may include:

- supporting research and management programs that respond to the economic, ecological, educational, recreational, scientific and aesthetic values of fish and wildlife;

- improving, where needed, fish and wildlife habitats;

- ensuring the presence of diverse, native and desired non-native populations of wildlife, fish, and plant species;

- providing research, educational, technical, and financial assistance to inform, encourage, and assist landowners to understand, apply, and improve management practices for fish and wildlife habitats;

- assisting with the improvement of opportunities for recreational uses of fish and wildlife, such as hunting, fishing, trapping, and viewing;

- encouraging and assisting the States, territories, and other Federal agencies in conducting resource inventories and evaluating the status and potential of fish and wildlife habitat...

Under Department authorities and mandates outlined above, the USDA-SCS entered into a cooperative agreement with the U.S. Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADF&G) to jointly conduct fish and wildlife investigations as part of the Susitna Cooperative River Basin Study. In particular, the SCS, working with these agencies, the ADNR, and the Matanuska-Susitna Borough:

1) identified potential problems and issues affecting long-term maintenance of sustainable populations of desired fish and wildlife species in the Basin to meet increasing human demands for these resources. The problems and issues identified are outlined in the Willow Subbasin Final Report (USDA 1981c) and in Land Use Issues and Preliminary Resource Inventory - Matanuska-Susitna-Beluga Cooperative Planning Program (ADNR et al. 1982)

2) analyzed the environmental base, and to some extent the economic base, affecting Basin fish and wildlife resources. Descriptions of environmental analyses conducted by the SCS in the Susitna River Basin are contained in the Willow Subbasin Final Report (USDA 1981c), in the Susitna River Basin Summary Report (USDA 1985), and in the various technical reports, such as this

one, accompanying the summary. (Other USDA technical reports are listed in Appendix A.) Descriptions of economic analyses conducted by the SCS/ERS are contained in the Willow Subbasin Final Report and in The Susitna Cooperative River Basin Study Economic Development Analysis: Talkeetna Subbasin (Fuglestad and O'Neill 1983). Technical assistance was also provided to the ADF&G during their attempts to develop an economic method for calculating monetary values of fish- and wildlife-related activities in the Susitna River Basin (ADF&G 1983b, 1983d).

3) developed fish and wildlife-oriented land use alternatives (element maps) to assist the State and Borough in addressing long-term maintenance of fish and wildlife resources in the Basin in ways compatible with improving the regional economy and the environment. Development and use of these alternatives are discussed in this and other reports cited above.

II. The Study Area

The Susitna River Basin includes approximately 14 million acres in Southcentral Alaska. Of this total, about one million acres lie in the Willow Subbasin (see USDA 1981c). The remainder of the Basin extends from Cook Inlet on the south, to the Alaska Range on the north, Clearwater Mountains on the northeast, Lake Louise area on the east, and Tordrillo Mountains on the west. Major stream systems include the Susitna, Talkeetna, Chulitna, Kahiltna, Skwentna, Yentna, and Beluga Rivers, as well as the lower reaches of the Chakachatna River. Lakes in the area number in the hundreds; among the larger of these are Lake Louise and Beluga Lake, as well as Alexander, Strandline, Trapper, Shulin, Chelatna, and Amber Lakes. The Basin is described in greater detail in the Susitna Basin Final Report (USDA 1985) and in accompanying technical reports, listed in Appendix A.

For study purposes, the Susitna River Basin was divided into three subbasins as shown in Figure 2. Environmental inventory data were collected by the FS and the SCS in shaded areas. Data collected in the Upper Susitna Subbasin were not as detailed as those collected in the other two subbasins. Technical analyses discussed in this report apply only in the shaded (data) areas shown on Figure 2.

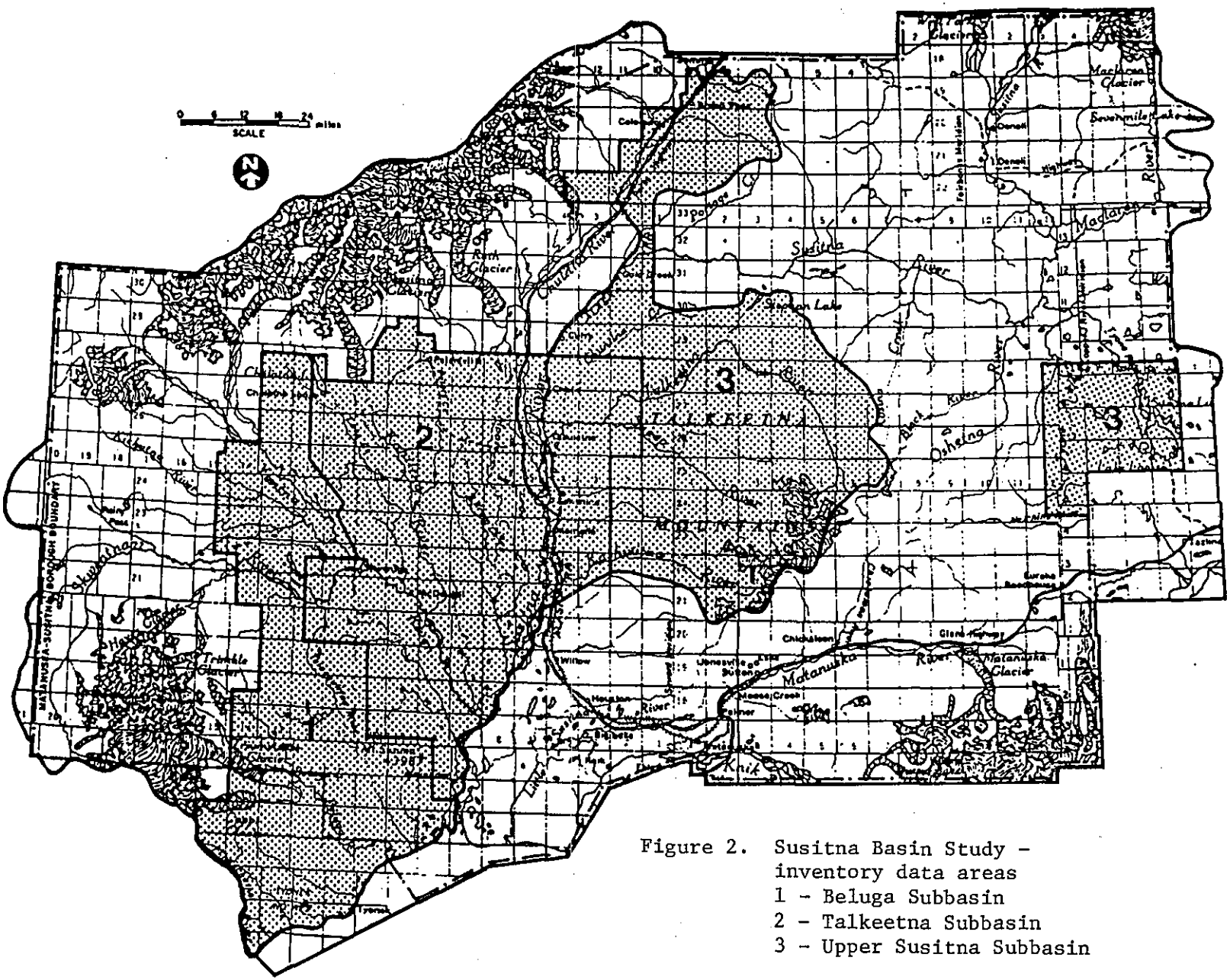


Figure 2. Susitna Basin Study - inventory data areas
1 - Beluga Subbasin
2 - Talkeetna Subbasin
3 - Upper Susitna Subbasin

III. Fish and Wildlife Resources in the Susitna River Basin[1/]

A. Fish and Wildlife Species

Many kinds of fish and wildlife are currently found in the Susitna Basin. These include big game species, such as moose, caribou, Dall sheep, black bear, and brown bear; furbearers, such as wolf, marten, wolverine, and mink; resident and anadromous fishes, such as salmon, trout, and grayling; small game; waterfowl; hawks and eagles; and a variety of others. Twenty-nine species of freshwater and anadromous fishes, 157 species of birds[2/], and 38 native mammal species (not counting Beluga whales and harbor seals, which may occur in Cook Inlet waters) are likely to breed in or migrate through the area (Tables 1, 2, and 3). For several species important to man (e.g., moose, black bear, beaver, etc.), Susitna River Basin populations are among the most abundant in Alaska and, in some cases, in the U.S. Estimated current numbers of six big game species found in the area are presented in Table 4. Where information was available, Table 4 also indicates what percentage of statewide populations are believed to occur in the Matanuska-Susitna Borough (generally equivalent to the Basin).

1/ For further information on Basin fish and wildlife resources, see ADF&G 1984

2/ One Federally listed threatened or endangered bird species is likely to migrate through the Basin: a threatened subspecies of the peregrine falcon (Falco peregrinus anatum). Two peregrines were sighted perched in an open stand of white spruce near timberline by an SCS biologist on August 2, 1981 (Beluga Subbasin, plot 65).

Table 1. Birds of the Susitna River Basin
(Sources: Anchorage Audubon Society, Inc. 1978, Armstrong 1980, Gabrielson and Lincoln 1959, Kessel and Gibson 1978, Kessel et al. 1982, Murie 1963, Ritchie et al. 1981)

GAVIIFORMES (loons)	
Common Loon	*Gavia immer*
Arctic Loon	*Gavia arctica*
Red-throated Loon	*Gavia stellata*
PODICIPEDIFORMES (grebes)	
Red-necked Grebe	*Podiceps grisegena*
Horned Grebe	*Podiceps auritus*
ANSERIFORMES (waterfowl)	
Whistling Swan	*Olor columbianus*
Trumpeter Swan	*Olor buccinator*
Canada Goose	*Branta canadensis*
Black Brant	*Branta nigricans*
White-fronted Goose*	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Blue-winged Teal	*Anas discors*
Northern Shoveler	*Anas clypeata*
European Wigeon	*Anas penelope*
American Wigeon	*Anas americana*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Common Goldeneye	*Bucephala clangula*
Barrow's Goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*
Oldsquaw	*Clangula hyemalis*
Harlequin Duck	*Histrionicus histrionicus*

* The Tule White-fronted Goose, a subspecies of the White-fronted Goose, may be nominated for inclusion on the endangered species list in the future (Cannon, personal communication, 1980).

White-winged Scoter	Melanitta deglandi
Surf Scoter	Melanitta perspicillata
Black Scoter	Melanitta nigra
Hooded Merganser	Lophodytes cucullatus
Common Merganser	Mergus merganser
Red-breasted Merganser	Mergus serrator

FALCONIFORMES (diurnal raptors)

Goshawk	Accipiter gentilis
Sharp-shinned Hawk	Accipiter striatus
Red-tailed Hawk	Buteo jamaicensis
Rough-legged Hawk	Buteo lagopus
Golden Eagle	Aquila chrysaetos
Bald Eagle	Haliaeetus leucocephalus
Marsh Hawk	Circus cyaneus
Osprey	Pandion haliaetus
Gyrfalcon	Falco rusticolus
Peregrine Falcon*	Falco peregrinus
Merlin	Falco columbarius
American Kestrel	Falco sparverius

GALLIFORMES (grouse, ptarmigan, chicken, quail, etc.)

Spruce Grouse	Canachites canadensis
Willow Ptarmigan	Lagopus lagopus
Rock Ptarmigan	Lagopus mutus
White-tailed Ptarmigan	Lagopus leucurus

GRUIFORMES (cranes, rails, etc.)

Sandhill Crane	Grus canadensis

CHARADRIIFORMES (shorebirds, gulls, etc.)

Semipalmated Plover	Charadrius semipalmatus
Killdeer	Charadrius vociferus
American Golden Plover	Pluvialis dominica
Black-bellied Plover	Pluvialis squatarola
Hudsonian Godwit	Limosa haemastica
Whimbrel	Numenius phaeopus
Greater Yellowlegs	Tringa melanoleuca
Lesser Yellowlegs	Tringa flavipes

* A Federal threatened subspecies of peregrine falcon (F. peregrinus anatum) is believed to migrate through and feed in the Susitna Basin.

Solitary Sandpiper	Tringa solitaria
Spotted Sandpiper	Actitis macularia
Wandering Tattler	Heteroscelus incanus
Ruddy Turnstone	Arenaria interpres
Northern Phalarope	Lobipes lobatus
Common Snipe	Gallinago gallinago
Short-billed Dowitcher	Limnodromus griseus
Long-billed Dowitcher	Limnodromus scolopaceus
Surfbird	Aphriza virgata
Sanderling	Calidris alba
Semipalmated Sandpiper	Calidris pusilla
Western Sandpiper	Calidris mauri
Least Sandpiper	Calidris minutilla
Baird's Sandpiper	Calidris bairdii
Pectoral Sandpiper	Calidris melanotos
Dunlin	Calidris alpina
Parasitic Jaeger	Stercorarius parasiticus
Long-tailed Jaeger	Stercorarius longicaudus
Glaucous Gull	Larus hyperboreus
Glaucous-winged Gull	Larus glaucescens
Herring Gull	Larus argentatus
Mew Gull	Larus canus
Bonaparte's Gull	Larus philadelphia
Arctic Tern	Sterna paradisaea
Marbled Murrelet	Brachyramphus brevirostris

COLUMBIFORMES (pigeons and doves)

Mourning Dove	Zenaida macroura

STRIGIFORMES (owls)

Great Horned Owl	Bubo virginianus
Snowy Owl	Nyctea scandiaca
Hawk Owl	Surnia ulula
Great Gray Owl	Strix nebulosa
Short-eared Owl	Asio flammeus
Boreal Owl	Aegolius funereus
Saw-whet Owl	Aegolius acadicus

CORACIIFORMES (kingfishers)

Belted Kingfisher	Megaceryle alcyon

PICIFORMES (woodpeckers)

Common Flicker	Colaptes auratus
Hairy Woodpecker	Picoides villosus
Downy Woodpecker	Picoides pubescens
Black-backed Three-toed Woodpecker	Picoides arcticus
Northern Three-toed Woodpecker	Picoides tridactylus

PASSERIFORMES (songbirds)

Say's Phoebe	Sayornis saya
Alder Flycatcher	Empidonax alnorum
Western Wood Pewee	Contopus sordidulus
Olive-sided Flycatcher	Nuttallornis borealis
Horned Lark	Eremophila alpestris
Violet-green Swallow	Tachycineta thalassina
Tree Swallow	Iridoprocne bicolor
Bank Swallow	Riparia riparia
Cliff Swallow	Petrochelidon pyrrhonota
Gray Jay	Perisoreus canadensis
Black-billed Magpie	Pica pica
Common Raven	Corvus corax
Black-capped Chickadee	Parus atricapillus
Boreal Chickadee	Parus hudsonicus
Red-breasted Nuthatch	Sitta canadensis
Brown Creeper	Certhia familiaris
Dipper	Cinclus mexicanus
Winter Wren	Troglodytes troglodytes
American Robin	Turdus migratorius
Varied Thrush	Ixoreus naevius
Hermit Thrush	Catharus guttatus
Swainson's Thrush	Catharus ustulatus
Gray-cheeked Thrush	Catharus minimus
Wheatear	Oenanthe oenanthe
Townsend's Solitaire	Myadestes townsendi
Arctic Warbler	Phylloscopus borealis
Golden-crowned Kinglet	Regulus satrapa
Ruby-crowned Kinglet	Regulus calendula
Water Pipit	Anthus spinoletta
Bohemian Waxwing	Bombycilla garrulus
Northern Shrike	Lanius excubitor
Orange-crowned Warbler	Vermivora celata
Yellow Warbler	Dendroica petechia
Yellow-rumped Warbler	Dendroica coronata
Townsend's Warbler	Dendroica townsendi
Blackpoll Warbler	Dendroica striata
Northern Waterthrush	Seiurus noveboracensis
Wilson's Warbler	Wilsonia pusilla
Red-winged Blackbird	Agelaius phoeniceus
Rusty Blackbird	Euphagus carolinus
Pine Grosbeak	Pinicola enucleator
Gray-crowned Rosy Finch	Leucosticte tephrocotis
Hoary Redpoll	Carduelis hornemanni
Common Redpoll	Carduelis flammea
Pine Siskin	Carduelis pinus
Red Crossbill	Loxia curvirostra
White-winged Crossbill	Loxia leucoptera

Savannah Sparrow	Passerculus sandwichensis
Dark-eyed Junco	Junco hyemalis
Tree Sparrow	Spizella arborea
White-crowned Sparrow	Zonotrichia leucophrys
Golden-crowned Sparrow	Zonotrichia atricapilla
Fox Sparrow	Passerella iliaca
Lincoln's Sparrow	Melospiza lincolnii
Song Sparrow	Melospiza melodia
Lapland Longspur	Calcarius lapponicus
Smith's Longspur	Calcarius pictus
Snow Bunting	Plectrophenax nivalis

Table 2. Mammals of the Susitna River Basin
(Sources: Kessel et al. 1982, MacDonald 1980, Manville and Young 1965, Youngman 1975)

INSECTIVORA (small insect-eating mammals)	
Masked Shrew	*Sorex cinereus*
Dusky Shrew	*Sorex monticolus*
Water Shrew	*Sorex palustris*
Arctic Shrew	*Sorex arcticus*
Pygmy Shrew	*Sorex hoyi*
CHIROPTERA (bats)	
Little Brown Bat	*Myotis lucifugus*
LAGOMORPHA (rabbits, hares, pika)	
Collared Pika	*Ochotona collaris*
Snowshoe Hare (varying hare)	*Lepus americanus*
RODENTIA (mammals with two chisel-shaped incisors in each jaw)	
Hoary Marmot	*Marmota caligata*
Arctic Ground Squirrel	*Spermophilus undulatus*
Red Squirrel	*Tamiasciurus hudsonicus*
Northern Flying Squirrel	*Glaucomys sabrinus*
Beaver	*Castor canadensis*
Northern Red-backed Vole	*Clethrionomys rutilus*
Meadow Vole	*Microtus pennsylvanicus*
Tundra Vole	*Microtus oeconomus*
Singing Vole	*Microtus miurus*
Muskrat	*Ondatra zibethicus*
Brown Lemming	*Lemmus sibiricus*
Northern Bog Lemming	*Synaptomys borealis*
Meadow Jumping Mouse	*Zapus hudsonius*
Porcupine	*Erethizon dorsatum*
Norway Rat *	*Rattus norvesicus*
House Mouse *	*Mus musculus*
CETACEA (whales, dolphins, porpoises)	
Beluga (white whale)	*Delphinapterus leucas*

* introduced

CARNIVORA (carnivorous mammals)

Coyote	Canis latrans
Wolf	Canis lupus
Red Fox	Vulpes vulpes
Black Bear	Ursus amaricanus
Brown (grizzly) Bear	Ursus arctos
Marten	Martes americana
Ermine (short-tailed weasel)	Mustela erminea
Least Weasel	Mustela nivalis
Mink	Mustela vison
Wolverine	Gulo gulo
River (Land) Otter	Lutra canadensis
Lynx	Felis lynx

ARTIODACTYLA (even-toed hoofed mammals)

Moose	Alces alces
Caribou	Rangifer tarandus
Mountain Goat	Oreamnos americanus
Dall Sheep	Ovis dalli

PINNIPEDIA (seals)

Harbor Seal	Phoca vitulina

Table 3. Fishes of the Susitna River Basin
(Source: Morrow 1980)

Petromyzontidae (lampreys)	
Pacific lamprey	*Entosphenus tridentatus*
Arctic lamprey	*Lampetra japonica*
Clupeidae (herring)	
Pacific herring	*Clupea harengus pallasi*
Salmonidae (whitefish, trout, salmon, grayling)	
Round whitefish	*Prosopium cylindraceum*
Bering cisco*	*Coregonus laurettae*
Rainbow trout/steelhead	*Salmo gairdneri*
Lake trout	*Salvelinus namaycush*
Dolly Varden	*Salvelinus malma*
Arctic charr	*Salvelinus alpinus*
Pink (Humpback) salmon	*Oncorhynchus gorbuscha*
Chinook (King) salmon	*Oncorhynchus tshawytscha*
Chum (Dog) salmon	*Oncorhynchus keta*
Coho (Silver) salmon	*Oncorhynchus kisutch*
Sockeye (Red) salmon/Kokanee	*Oncorhynchus nerka*
Arctic grayling	*Thymallus arcticus*
Osmeridae (smelts)	
Pond smelt	*Hypomesus olidus*
Surf smelt	*Hypomesus pretiosus*
Eulachon (Hooligan)	*Thaleichthys pacificus*
Umbridae (mudminnows and blackfish)	
Alaska blackfish	*Dallia pectoralis*
Esocidae (pikes)	
Northern pike	*Esox lucius*
Catostomidae (suckers)	
Longnose sucker	*Catostomus catostomus*

* observed spawning near Talkeetna by ADF&G biologists (Trent, personal communication, 1981)

Gadidae (codfishes)	
Burbot	Lota lota
Gasterosteidae (sticklebacks)	
Threespine stickleback	Gasterosteus aculeatus
Ninespine stickleback	Pungitius pungitius
Cottidae (sculpins)	
Slimy sculpin	Cottus cognatus
Coastrange sculpin	Cottus aleuticus
Pacific staghorn sculpin	Leptocottus armatus
Sharpnose sculpin	Clinocottus acuticeps
Pleuronectidae (flounders)	
Starry flounder	Platichthys stellatus

Table 4. Big game population estimates for the Susitna River Basin/Matanuska-Susitna Borough

Species	Estimated Borough Population[1/]	Estimated % of State Population[2/]	Preferred Habitats
moose	49,000	25–50%	Young forests, especially deciduous and mixed forests; low and tall shrublands with willow, birch, aspen, poplar, cottonwood, alder, lowbush cranberry, and other woody browse; freshwater wetlands, including muskegs, bogs, marshes; forested and shrubby stream and river valleys
brown bear	1,000	10–20%	open tundra and grasslands; but also uses a wide variety of shrub and forest habitats, especially if they are relatively open
black bear	2,000	10%	forests and woodlands; preferred areas seem to be semi-open forested areas with understory vegetation of fruit-bearing shrubs, herbs, lush grasses, and succulent forbs
Dall sheep	6,000–8,000	12–16%	steep grasslands and tundra in alpine zone characterized by cliffs, deep canyons, rock outcrops, and other types of "escape terrain"
mountain goat	300	—	alpine and subalpine areas in the Talkeetna and Chugach Mountains with grasses, sedges, and forbs; in winter, prefers rocky wind-blown ridges where forage remains accessible
wolf	800–1,000	8–13%	all habitats in which preferred prey species (e.g., moose, caribou, small game, etc.) are available.

1/ Source: ADF&G 1982a

2/ Source: derived from state population estimates in Rearden (ed) 1981

B. Fish and Wildlife Habitats

The place where an animal normally lives and finds food, shelter, and opportunities to reproduce is called its "habitat." Habitats are usually characterized by dominant plant forms (e.g., forest or grassland habitats) or by dominant physical conditions (e.g., stream or talus slope habitats). Because particular habitats support particular animal species, an area with many kinds of habitats is generally more likely to support a diverse fauna than a more homogeneous area, especially if the former is also characterized by relatively stable climatic conditions and productive plant communities.

These principles explain why, in comparison with much of the rest of the State, the Susitna River Basin generally supports a relatively diverse and abundant fauna. A large variety of habitats is available because the Basin encompasses a wide range of landforms, localized environments, and plant communities. Basin habitats include coastal mudflats and tidelands, estuaries, rivers and streams, flood plains, marshes, deciduous and coniferous forests, shrublands, grasslands, muskegs, alpine tundras, and windswept peaks. In addition, Basin climates are generally mild compared to climates in most other areas of the State, and as a result many Basin plant communities are relatively productive. High productivity of nutritious and palatable plant species provides the foundation for large fish and wildlife populations.

Plant communities are commonly used as the mapping units for wildlife habitats. These communities can be classified at many levels, from general description ("hardwood forest") to detailed statistical quantification ("paper birch forest with 75% tree canopy closure, 800 stems of pole- and sawtimber-size birch per hectare, 5 stems of sapling-size birch per hectare; tall shrub layer composed of an average 15,000 stems per hectare of wild rose and 12,000 stems per hectare of high-bush cranberry; herb layer of ..." etc.) The level of classification chosen reflects the needs and knowledge of those using the classification system. In the Susitna Basin study, the classification system used to assess suitability of Basin habitats for individual wildlife species is more detailed than that used when comparing habitats in terms of relative scarcity or wildlife species diversity.

In the Susitna River Basin, 30 different plant communities, as well as 9 other non-vegetated "cover types," were mapped and computer automated* (Table 5). Cover-type categories were combined as needed for wildlife modeling. In Table 6, the 39 original mapped cover types have been combined into 15 general habitat categories. Acreages and percent-of-subbasin covered by general habitat categories in inventoried areas are also indicated in Table 6. Tables 7 and 8 list some of the birds and mammals

* Computer automation of Susitna Basin inventory data is discussed in ESRI 1982.

Table 5 LAND COVER MAPPING UNITS

VEGETATED			NON-VEGETATED
FOREST AND WOODLAND - more than 10% Crown Cover		NON-FOREST - less than 10% Crown Cover	
CLOSED FOREST 50% crown cover	OPEN FOREST-WOODLAND 10-50% crown cover	SALT WATER WETLANDS 50-grassland 51-low shrub 52-tidal marsh	OTHER 70-Cultural Influence 71-Tyonek Timber Sale
CONIFEROUS FOREST WHITE SPRUCE 21-short stands <30 ft 25-tall stands >30 ft	CONIFEROUS FOREST WHITE SPRUCE 31-short stands <30 ft 33-tall stands >30 ft	TALL SHRUB 60-alder 61-alder-willow (streamside veg.)	BARREN 80-mud flats 81-rock
BLACK SPRUCE 41-short stands <10 ft 42-tall stands >10 ft	BLACK SPRUCE 43-short stands <10 ft	LOW SHRUB 62-willow-resin birch	PERMANENT SNOW AND ICE 82-snowfield 83-glacier
MOUNTAIN HEMLOCK 45-short stands <30 ft 46-tall stands >30 ft		63-GRASSLAND	WATER 91-lakes >40 ac. 92-lakes 10 ac.— 40 ac. 96-streams and rivers 165 ft — 660 ft wide 97-river>1/8 mile wide (660 ft)
DECIDUOUS FOREST Closed Deciduous-Closed Mixed 22-young stands <40 yrs 24-medium-aged stands 20-80 yrs 26-old stands >80 yrs	DECIDUOUS FOREST Open Deciduous-Open Mixed 32-medium-aged stands 40-80 yrs 34-old stands >80 yrs	TUNDRA 64-sedge-grass 65-herbaceous 66-shrub 67-mat and cushion	
COTTONWOOD 27-young stands <40 yrs 28-medium-aged stands 40-100 yrs 29-old stands >100 yrs	COTTONWOOD 35-medium-aged stands 40-100 yrs 36-old stands >100 yrs	FRESH WATER WETLANDS 68-sphagnum bog 69-sphagnum-shrub bog	

Table 6. Summary of selected plant community (wildlife habitat) acreages

VEGETATION TYPES* (SCS map codes)	SUBBASINS							
	WILLOW 1/		TALKEETNA		UPPER SUSITNA		BELUGA	
	acres	% of Subbasin	acres	% of Subbasin	acres	% of Subbasin	acres	% of Subbasin
1. Open mixed forest (32,34)	276,010	28.48	57,760	2.49	11,600	.61	155,810	10.74
2. Closed mixed forest (24,26)			628,770	27.11	37,720	2.00	203,040	14.00
3. Open conifer forest (31,33)	172,010 (includes 43)	17.75	67,070	2.89	20,400	1.08	5,210	.36
4. Closed conifer forest (21,25,41,42)			153,850	6.63	17,240	.91	49,410	3.41
5. Open deciduous forest (35,36)	3,390	.35	1,740	.08	2/	2/	5,770	.40
6. Closed deciduous forest (22,27,28,29)			12,880	.56	2,720	.14	6,150	.42
7. Tall riparian shrub-alder, willow (61)	49,670	5.12	136,280	5.88	20,680	1.09	59,420	4.10
8. Tall shrubs-alder (60)			487,700	21.03	342,440	18.12	435,000	29.99
9. Low shrubs-willow, resin birch (62)	12,730 (includes 66)	1.31	13,250	.57	105,920	5.61	16,280	1.12
10. Saltwater wetlands-grass, sedge, shrub (50,51,52)	23,370	2.41	11,380	.49	0	0	18,940	1.30
11. Black spruce forests, muskegs, sphagnum bogs (43,68,69)	(43 included above; 68,69 not totaled)	-	528,070	22.77	5,400	.29	218,150	15.04
12. Grassland (63)	194,580	20.07	29,130	1.26	1,120	.06	25,650	1.77
13. Tundra 3/ (64,65,66,67)	145,150 (excludes 66)	14.98	68,160	2.94	1,106,960	58.58	160,250	11.05
Total vegetated acres	876,910 1/	90.47 1/	2,196,040	94.69	1,672,200	88.49	1,359,080	93.71
14. Water-lakes, streams (91,92,96,97)	92,360 1/	9.53 1/	99,830	4.30	8,280	.44	33,990	2.34
15. Non-vegetated (70,80,81,82,83)			23,380	1.01	209,240	11.07	57,350	3.95
Total acres	969,270	100.00	2,319,250	100.00	1,889,720	100.00	1,450,420	100.00

* Vegetation types are described in detail in: Susitna River Basin Vegetation Report (USDA in progress).

1/ Willow Subbasin plant community classes are not directly comparable to classes in other subbasins, acreages presented here are therefore rough totals.

2/ Minimum mapping unit in this subbasin was 40 acres rather than 10 acres, therefore, plant communities occurring in small scattered parcels (polygons) do not appear on the map.

3/ In Willow Subbasin, shrub tundra (SCS 66) is combined with low shrub acreage (SCS 62).

likely to use particular habitats. Tables such as these can be used by planners and others interested in having information such as:

1) which habitats are likely to be used by wildlife species of interest,
2) how abundant particular habitats are in various subbasins,
3) which habitats are likely to be used by many wildlife species and which by few,
4) which wildlife species use many habitats and which use only a few,
5) which wildlife species are likely to be affected by alterations of particular habitats,
6) which habitats are increasing or decreasing over time, and by how much (remapping after several years would be required for such comparisons).

Table 7. Preferred habitats for selected Susitna Basin mammals

SELECTED SPECIES	Coniferous forests (open or closed)	Deciduous forests (open or closed)	Mixed forests (open or closed)	Riparian* forests	Upland tall shrubs-alder	Riparian* tall shrubs-alder and/or willow	Upland low shrubs-willow, resin birch	Riparian* low shrubs	Herbaceous freshwater wetlands (sedge, grass)	Grasslands	Shrub tundra	Other tundra (herbaceous, mat & cushion, sedge-grass)
1. masked shrew	X	X	X	X	X	X	X	X	X	X	X	X
2. pika										alpine		X
3. snowshoe hare	X	X	X	X	X	X	X	X		w/cover	X	
4. hoary marmot										alpine		X
5. arctic ground squirrel										alpine		X
6. red squirrel	X		X	X								
7. northern flying squirrel	X		X	X								
8. beaver				X		X		X				
9. northern red-backed vole	X	X	X	X	X	X	X	X		X	X	X
10. muskrat				X		X		X	X			
11. northern bog lemming	--moist--			X		X		X	X	moist		X
12. meadow jumping mouse	--open---			X		X		X	X	moist		
13. porcupine	X	X	X	X								
14. coyote	X	X	X	X	X	X	X	X	X	X	X	X
15. grey wolf	X	X	X	X	X	X	X	X	X	X	X	X
16. red fox	--open---			X	X	X	X	X	X	X	X	X
17. black bear	X	X	X	X		X	X	X	X		X	
18. brown bear	--open---			X		X	X	X	X	X	X	X
19. marten	X		X	X								
20. short-tailed weasel	--open---			X		X		X		w/cover	X	X
21. mink	--edges--			X		X		X	X			
22. wolverine	X	X	X	X	X	X	X	X			X	X
23. river otter				X		X		X	X			
24. lynx	X	X	X	X	X	X	X	X			X	X
25. moose	X	X	X	X	X	X	X	X	X	w/cover	X	
26. caribou	X						X	X	X	alpine	X	X
27. mountain goat	in winter				X		spring			alpine	X	X
28. Dall sheep					near treeline		spring			alpine	X	X

* "Riparian" habitats are defined as those plant communities near enough rivers, streams, ponds, or lakes for these water bodies to be readily accessible to mammal species in question. This distance varies with size and mobility of particular species.

Table 8. Preferred habitats[+] for nesting (n), feeding (f), or both (b) for selected Susitna Basin birds

SELECTED SPECIES	SELECTED HABITATS	Coniferous forests (open or closed)	Deciduous forests (open or closed)	Mixed forests (open or closed)	Riparian* forests	Upland tall shrubs-alder	Riparian* tall shrubs-alder and/or willow	Upland low shrubs-willow, resin birch	Riparian* low shrubs	Herbaceous freshwater wetlands (sedge, grass)	Grasslands	Shrub tundra	Other tundra (herbaceous, mat & cushion, sedge-grass)	In or by streams or rivers	In or by lakes, ponds, or sloughs	Cliffs
1. common loon					b										b	
2. horned grebe															b	
3. trumpeter swan					b					f					b	
4. mallard					b					b				b	b	
5. green-winged teal					b					b				b	b	
6. harlequin duck					b									b		
7. bald eagle					n									f	f	n
8. marsh hawk									b	b						
9. gyrfalcon								f	f	f	f	f	f			n
10. spruce grouse		b		b	b											
11. willow ptarmigan								b	b			b				
12. spotted sandpiper														b	b	
13. mew gull										b			b	b	b	
14. arctic tern														b	b	
15. great horned owl		b	b	b	b											n
16. hawk owl		b	b	b	b											
17. belted kingfisher					b									b	b	
18. hairy woodpecker			b	b												
19. northern 3-toed woodpecker		b														
20. alder flycatcher						b	b	b	b							
21. tree swallow					b									f	f	
22. gray jay		b	f	b	b											
23. common raven		b	b	b	b	f	f	f	f	f	f	f	f	f	f	n
24. dipper														b		n
25. wilson's warbler		-----b in shrub thickets-----														
26. common redpoll			b	b	b	b	b	b	b		f	b				
27. snow bunting												b	b			n

+ Marine coastal habitats not included.

* "Riparian" habitats are defined as those plant communities near enough rivers, streams, ponds, or lakes for these water bodies to be readily accessible to particular bird species.

C. Human Uses of Basin Fish and Wildlife

Comprehensive data on all human uses of Basin fish and wildlife are not collected; however, available ADF&G data indicate that well over 300,000 days are spent each year harvesting big game, small game, furbearers, waterfowl, and fish species in the Matanuska-Susitna Borough. Because of its proximity to major population centers, and its diverse and abundant fish and wildlife, a substantial percentage of statewide hunting and fishing effort occurs in the Basin. The ADF&G (1984) estimates that 15% of sport fishing effort, over 40% of moose hunting effort, 23% of caribou hunting effort, as well as 17% of the sheep harvest in the State take place within the Borough. This represents very high human use of Basin fish and wildlife in light of the fact that the Borough represents only about 4% of total State area, and not all Borough lands are used by hunters or anglers because some are inaccessible to them and others do not provide suitable habitats for harvested species. (For an economic analyses of some of these uses, see USDA 1985).

As noted previously, seven species of big game (moose, caribou, Dall sheep, wolf, wolverine, black and brown bear) may be locally abundant during particular seasons, and are hunted in appropriate habitats throughout the area (see Table 4). In addition to big game, a variety of small game, furbearers, and waterfowl are trapped and hunted in the Basin, including red fox, lynx, beaver, marten, muskrat, mink, river otter, snowshoe hare, spruce grouse, three species of ptarmigan, and fifteen kinds of ducks and geese.

Furbearers are particularly abundant along river and stream corridors and around ponds and lakes; while 50,000 to 100,000 ducks and geese may migrate through Cook Inlet coastal marshes in spring and fall.

The numerous streams and associated pond and lake complexes in the Basin provide suitable habitats for migration, spawning, and rearing of a variety of fish species important to man. The Susitna River and its tributaries are estimated to contribute approximately 50–60% of the Upper Cook Inlet commercial salmon harvest (ADF&G 1982a). In addition, fish populations, especially anadromous species such as salmon, steelhead, and Dolly Varden, support important recreational and subsistence fisheries. (Spawning salmon and salmon carcasses also become important food for birds and mammals.) Nonanadromous species are also fished in the area, including rainbow trout, nonanadromous Dolly Varden, lake trout, Arctic grayling, northern pike, burbot, and whitefish. Tables 9 and 10 provide information on angler days per stream and sport fish harvests 1977–1981 in the study area.

Many nongame species also find suitable habitats throughout the Basin, and are enjoyed by hikers, birders, photographers, and other "non-consumptive" recreationists. Raptors, such as golden and bald eagles, great horned owls, red-tailed hawks, and marsh hawks, breed in the area, as do a variety of wading and shorebirds, woodpeckers, and songbirds. Many bird species that do not nest in the Basin depend on area habitats during migration, among them probably a threatened subspecies of peregrine falcon (Falco peregrinus anatum). Small mammals, such as shrews, voles, marmots, lemmings, and

others provide entertaining wildlife viewing and are important prey species for carnivorous furbearers and big game. Non-game wildlife also benefit human societies by controlling insect outbreaks, pollinating plants, dispersing and planting seeds, mixing soil, and performing a variety of other ecological roles.

Table 9. Susitna Basin sport fishing effort and harvests by species - 1980 (Willow Subbasin excluded) (source: ADF&G 1983d)

Fisheries	Days Fished	Species Harvested KS	SS	LL	RS	PS	CS	RT	DV AC	LT	GR	NP	WF	BB	Other	Total Harvest
Glennallen Area																
Lake Louise, Lake Susitna, Tyone Lake	10,539	0	0	0	0	0	0	0	0	2,609	4,477	0	1,688	6,612	0	15,386
other waters (x 35%)	5,823	145	57	75	301	0	0	461	292	784	5,985	0	63	687	341	9,191
Total	16,362	145	57	75	301	0	0	461	292	3,393	10,462	0	1,751	7,299	341	24,577
Eastside Susitna River Drainages																
Caswell Creek	4,963	215	1,124	0	77	1,663	19	154	83	0	353	0	0	26	26	3,740
Montana Creek	19,287	559	2,684	0	257	8,230	571	854	167	0	655	0	0	13	13	14,003
Sunshine Creek	5,208	13**	1,534	0	116	2,408	225	193	39	0	0	0	0	39	0	4,567
Clear (Chunilna) Creek	4,388	172	661	0	6	622	385	950	751	0	1,348	0	0	32	32	4,959
Sheep Creek	8,041	45**	430	0	0	6,362	648	385	83	0	725	0	0	45	0	8,723
Others	12,216	45**	2,234	1,663	257	3,403	1,445	2,658	790	267	4,854	0	0	212	520	18,348
Total	54,103	1,049	8,667	1,663	713	22,688	3,293	5,194	1,913	267	7,935	0	0	367	591	54,340
Westside Susitna River Drainages																
Kroto Creek (Deshka)	19,364	3,685	2,290	0	0	689	0	4,305	0	0	1,817	0	0	224	69	13,079
Lake Creek	8,325	775	2,351	0	267	2,101	69	2,144	121	0	1,972	103	0	0	0	9,903
Alexander Creek	6,812	1,438	999	0	52	809	121	1,945	353	0	1,145	0	0	0	0	6,862
Talachulitna River	2,542	121**	491	0	112	276	17	379	982	0	1,713	0	0	0	0	4,091
Chuit River	614	17**	258	0	0	69	0	301	146	0	0	0	0	0	0	791
Theodore River	700	17**	370	0	0	232	0	250	129	0	0	0	0	0	0	998
Lewis River	43	0	0	0	0	0	0	9	0	0	0	0	0	0	0	9
Other Rivers	4,998	129**	6,010	0	34	362	284	1,722	603	181	1,808	0	0	448	0	11,581
Shell Lake	414	0	0	0	198	0	0	103	0	69	0	0	0	0	0	370
Whiskey Lake	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hewitt Lake	471	0	0	0	0	0	0	9	0	0	0	0	0	0	0	9
Judd Lake	814	0	0	0	267	0	0	86	723	0	232	0	0	0	0	1,308
Other Lakes	2,999	0	0	0	181	0	0	2,092	43	198	560	129	0	34	34	3,271
Total	48,125	6,182	12,769	0	1,111	4,538	491	13,345	3,100	448	9,247	232	0	706	103	52,272
GRAND TOTAL	118,590	7,376	21,493	1,738	2,125	27,226	3,784	19,000	5,305	4,108	27,644	232	1,751	8,372	1,035	131,189
Total Poundage		171,000/968	125,000	1,740	12,500	89,800	27,600	19,000	5,300	10,300	30,400	696	2,280	29,300	1,000	527,000

Source: Mills, Michael J. 1981. Statewide Harvest Study - 1980 data. ADFG, Division of Sport Fish, Juneau. Extracted from Tables 42, 44 and 45.

Species Harvested and average weights (lbs): Chinook salmon (KS) 24.4/2.2, Coho salmon (SS) 5.8, Landlocked Coho salmon (LL) 1.0, Sockeye salmon (RS) 5.9, Pink salmon (PS) 3.3, Chum salmon (CS) 7.3, Rainbow trout (RT) 1.0, Dolly Varden/Arctic char (DV/AC) 1.0, Lake trout (LT) 2.5, Arctic grayling (GR) 1.1, Northern pike (NP) 3.0, Whitefish (SF) 1.3, Burbot (BB) 3.5. (Source for poundages: ADF&G, Division of Commercial Fisheries, and ADF&G, Division of Sport Fish, Pers. Comm., L. Engel 3/83; and, Morrow, James E., 1980. The Freshwater Fishes of Alaska. Alaska Northwest Publishing Company, Anchorage.

** King salmon less than 20 inches.

Table 10. Susitna Basin total sport fishing days and harvests: 1977-1981 (Willow Subbasin excluded) (source: ADF&G 1983d)

Fisheries	1977 Days	1977 Harvest	1978 Days	1978 Harvest	1979 Days	1979 Harvest	1980 Days	1980 Harvest	1981 Days	1981 Harvest	Average Days	Average Harvest
Glennallen Area												
Lake Louise, Lake Susitna & Tyone Lake	14,899	10,624	13,161	8,419	12,199	8,953	10,539	15,386	14,397	15,941	13,039	11,865
Other Waters (X 35%)	7,746	10,308	4,667	7,914	6,613	11,909	5,823	9,191	5,354	9,231	6,040	9,711
Eastside Susitna Drainage												
All waters except Willow Creek & Little Willow Creek	38,044	33,163	57,641	67,608	54,140	38,552	54,103	54,340	41,949	35,884	49,175	45,909
Westside Susitna Drainage												
All Freshwater Areas	31,946	39,606	38,771	48,287	50,374	48,938	48,125	52,272	37,335	36,110	41,310	45,043
Total	92,635	93,701	114,240	132,228	123,326	108,352	118,590	131,189	99,035	97,166	109,565	112,528
(Total Less Pink Salmon)		(73,727)		(97,310)		(99,435)		(103,963)		(91,774)		(99,242)
Percent of Statewide Totals	7.7	9.6	8.8	12.7	9.0	8.3	7.9	10	7.0	10	8.1	10.1

Source: Mills, Michael J. 1977-1981. Statewide Harvest Studies. Selected from appropriate tables. "Days" are days of active fishing, all anglers. "Harvest" denotes all fish taken, all species included, but does not include catch and release fisheries.

D. Future of Fish and Wildlife Resources

Resource maps and inventory data presented in Susitna Basin Study reports reflect environmental conditions existing at the time of the study. These conditions are continually changing, both as a result of natural events, such as floods, fires, earthquakes, landslides, glacial advances and retreats, and soil erosion and deposition; and as a result of human activities, such as mining, logging, farming, and construction of roads, dams, houses, etc. As conditions change, so do affected plant communities and fish and wildlife habitats.

Some environmental changes are relatively predictable. Their effects on fish and wildlife habitats and populations can, therefore, be anticipated and often modified. Changes caused by human activities provide good examples. Habitat impacts of mining, logging, or farming, for example, can generally be anticipated. If information on existing conditions is available, as in the Basin, plans can then be developed to avoid or reduce negative effects of such activities on fish and wildlife. Some natural changes can also be predicted to some extent and, therefore, planned for appropriately. Examples include: 1) probable frequency and extent of flooding (see USDA 1981a and b, 1982a, b, and c) and 2) successional changes in plant communities. Changes associated with plant succession are particularly important to wildlife because different animal species find optimum habitats in different successional stages. Figures 3a and 3b illustrate two successional sequences occurring in the Basin, and identify a

few of the wildlife species that may use habitats provided by different successional stages. Figure 4 provides a more complex indication of possible successional sequences following fires on different sites.

Often, if environmental changes are understood, they can be deliberately manipulated to benefit fish and wildlife: impoundments can be constructed to create aquatic and wetland habitats; plant succession can be accelerated by seeding or planting desirable species; plant succession can be slowed by cutting, burning, or mechanical crushing; development activities such as road building, farming, etc. can be directed to areas of lesser importance for fish and wildlife through community planning and zoning. Whether a change is seen as beneficial or detrimental will depend on which fish and wildlife species are affected, what human activities will have to be curtailed or modified to accommodate affected species, and the personal opinions of those involved.

It is important for land planners and users to remember that change is intrinsic to natural environments, and that, as a result, habitats and the faunas they support will vary over time. Where human activities occur, habitat and faunal changes are often dramatically increased. The future availability of fish and wildlife resources in the Basin will depend on how those changes affecting fish and wildlife, especially those affecting

Fig. 3a Successional stages following fire - upland white spruce sites (adapted from Viereck and Schandelmeier 1980)

1. Newly burned: This stage lasts a few weeks to a year.

2. Herb-tree seedling stage: One to 5 years after the fire, fast-growing mosses and herbs and tree seedlings are established.

3. Shrub (willow) and tree sapling stage: In this stage, 6 to 25 years after fire, the willow shrubs and tree saplings dominate the stands and form a nearly continuous canopy, which begins to shade out the herbaceous and moss layer.

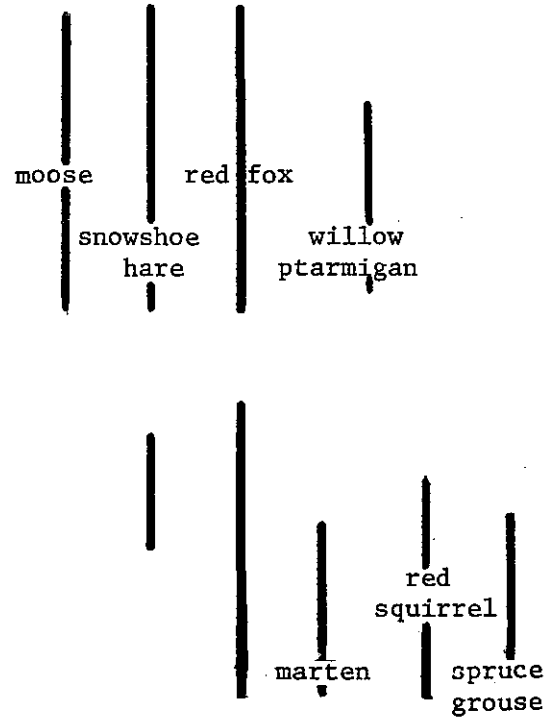
4. Dense hardwood stage: Birch and aspen form a dense canopy that tends to shade out much of the understory that has developed since the fire.

5. Mature hardwood stage: Aspen stands mature at about 80 years. Birch stands then gradually open through natural thinning.

6. Mature birch and white spruce: At 100 years and more, the successional sequence reaches a stage in which mature white spruce stands, often with a component of old birch trees, are dominant.

7. White spruce/moss: The mature stands are composed of white spruce with thick moss mats on the forest floor.

Selected species using stages



Although some authors consider the white spruce stands to be the climax vegetation of these sites, it has also been suggested that some old upland white spruce stands may be replaced by black spruce and bog or a treeless moss/lichen association as permafrost develops under the accumulating moss and organic layers.

*Successional chronology and pattern on particular sites vary with factors such as preburn vegetation, proximities and types of seed source, time and severity of fire, presence or absence of permafrost, occurrence of natural or cultural disturbances; as well as with site-specific conditions such as slope, soil, aspect, climate, etc.

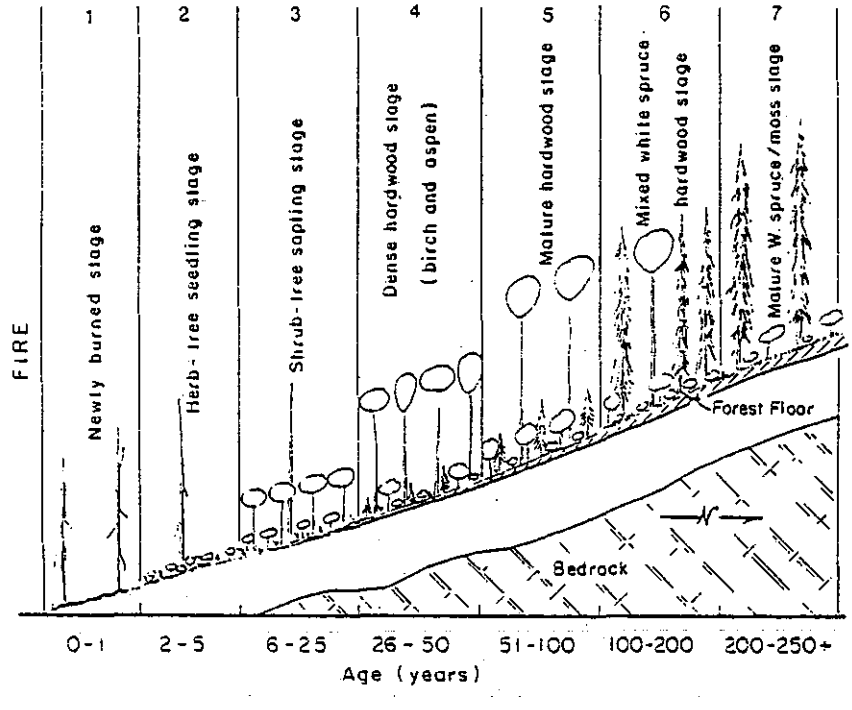


Fig. 3b Successional stages following fire - permafrost black spruce sites (adapted from Viereck and Schandelmeier 1980)

1. Newly burned: Lasts from a few weeks to a year. At this stage the forest floor is dominated by charred mosses and mineral ash. If the burn is light to moderate, sucker shoots of shrubs, Calamagrostis, and Polytrichum may appear.

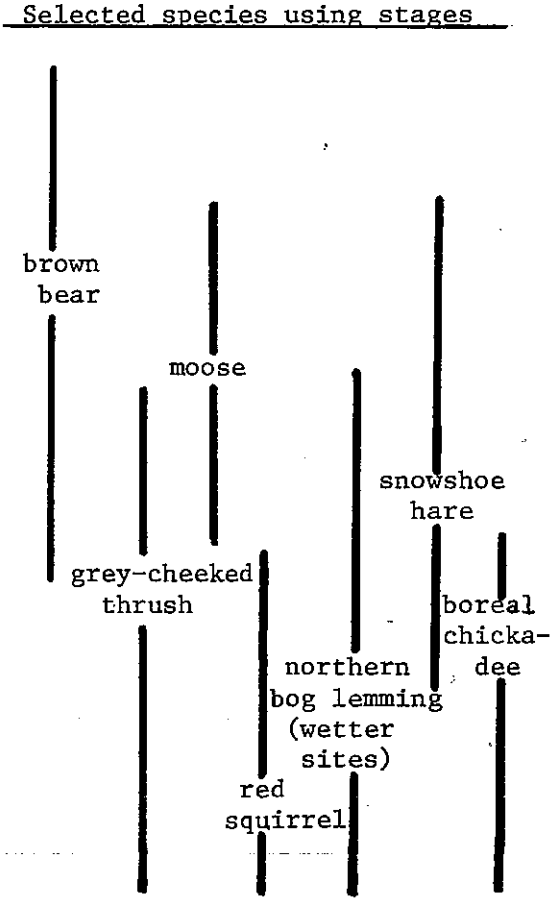
2. Herbaceous-young shrub stage: Lasts from 1 to 4 years and is the time of species establishment. Bare mineral soil areas are covered with Marchantia, Ceratodon purpureus, Polytrichum commune, Epilobium angustifolium, tree seedlings, etc. Sprouting species, primarily Calamagrostis canadensis, Rubus chamaemorus, and Equisetum silvaticum, become abundant.

3. Shrub stage: The shrubs dominate the vegetation. Toward the end of this stage, the shrub canopy closes, leaf litter becomes abundant, herb and moss cover increases, and the first lichens, usually the foliose lichens Peltigera canina and P. aphthosa, become established. This stage usually occurs from 6 to 25 years after fire.

4. Young black spruce: This stage occurs 26 to 50 years after fire. Stands are usually dense. Toward the end of this stage, the spruce canopy becomes closed and the shrubs reduced in cover.

5. Dense black spruce - Pleurozium stage: The stage occurs 51 to 100 years after the fire. Black spruce, low shrubs, and Pleurozium schreberi dominate.

6. Mature black spruce/feathermoss stage: This is the final stage in the postfire succession. Black spruce trees, saplings, and seedlings dominate the stand.



The last three stages are dominated by trees. The tall shrub layer of willows and alders begins to thin out, but the low shrub layer continues to expand and increase in cover. The invasion and rapid development of feathermoss, fruticose lichens, and additional foliose lichens occurs, and a thick organic layer develops. This layer ties up the available nutrients, creates colder soil temperatures, and results in the return of a shallow active soil layer on many sites.

*Successional chronology and pattern on particular sites vary with factors such as preburn vegetation, proximities and types of seed source, time and severity of fire, presence or absence of permafrost, occurence of natural or cultural disturbances; as well as site-specific conditions such as slope, soil, aspect, climate, etc.

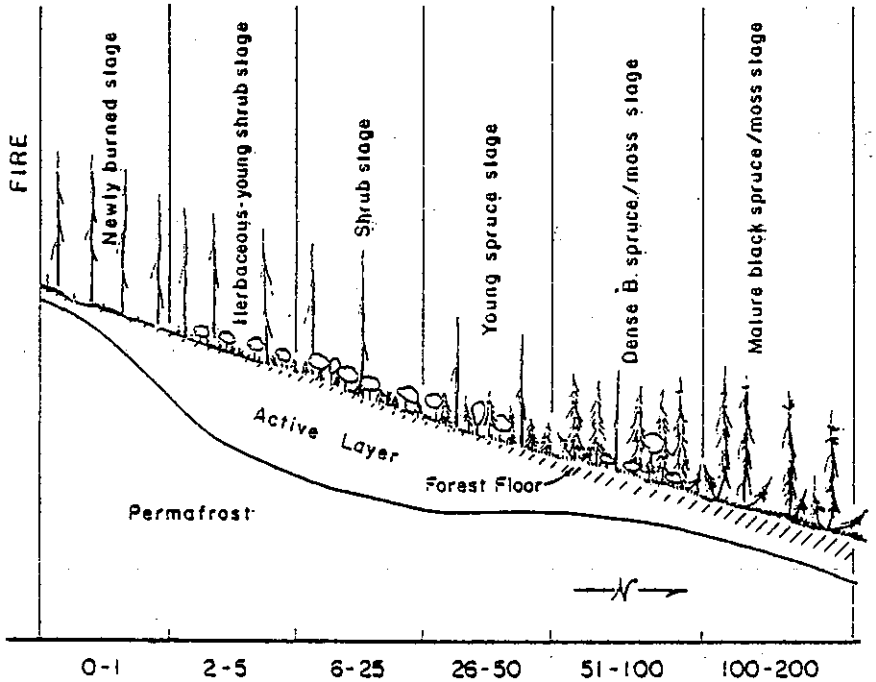


Figure 4. Patterns of forest succession following fire in Alaska (source: Viereck and Schandelmeier 1980)

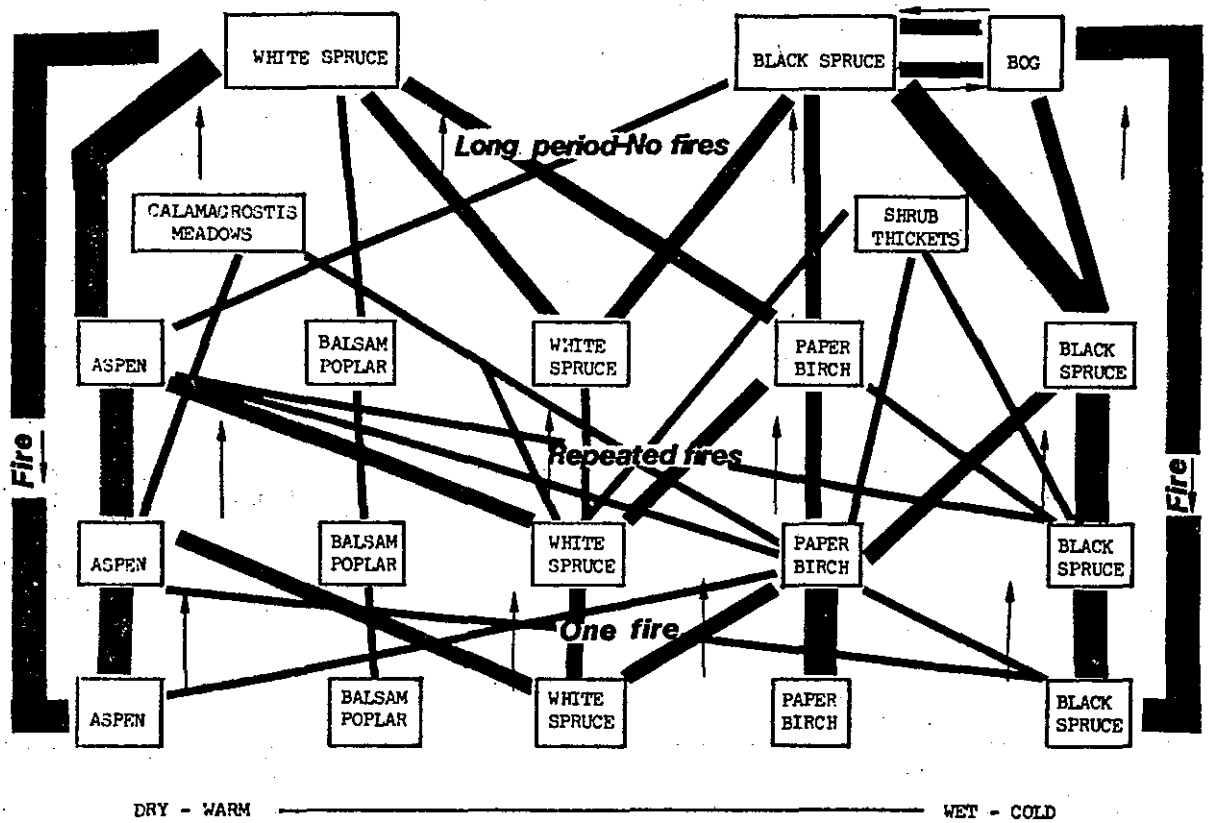


Figure 4 shows some of the many paths of revegetation that have been observed following fire in interior Alaska. The original preburn forest type is shown on the bottom row of boxes. The thickness of the line is related to how commonly each of the revegetation sequences occurs. Thus, black spruce is usually replaced directly by other stands of black spruce but occasionally is replaced by aspen or birch. Aspen stands, usually on warm dry sites, are most often replaced by other aspen stands but occasionally are revegetated by birch or a grass meadow after fire. Eventually, with a long period without fire, the aspen stands are invaded by white spruce or occasionally black spruce. The climax vegetation on well-drained sites is white spruce and on cold wet sites black spruce, often with an alternating bog cycle (Viereck and Schandelmeier 1980).

habitats, are understood and managed. Understanding and managing habitat change requires:

1) knowledge of existing habitat conditions,
2) ability to assess relative fish and wildlife values of various Basin habitats,
3) ability to predict changes, both natural and manmade, probable in Basin habitats (including effects of such changes on particular species), and
4) the authority and means to implement habitat-use and management decisions made on the basis of available knowledge.

Reports, maps, and other sources of data produced during the Susitna Basin Study provide information on existing habitat conditions and on how these conditions may change. Section IV of this report discusses methodologies for assessing relative fish and wildlife values of Basin lands, which can also be useful in assessing effects of habitat changes. Area planning, conducted jointly by the State and the Matanuska-Susitna Borough, with technical assistance from the SCS and the USFWS, provides the authority to make general decisions concerning uses of Basin lands and waters. And finally, more detailed Management Plans provide the means for designing and implementing selected land and water uses in ways most beneficial for fish and wildlife.

IV. Fish and Wildlife Modeling and Mapping in the Susitna River Basin

A. Introduction

The following sections describe the technical fish and wildlife analyses conducted by the SCS as part of the Susitna Cooperative River Basin Study. These analyses consisted of two main activities: 1) working with the USFWS and the ADF&G to develop ways to use River Basin data in "modeling" the relative fish and wildlife values of Basin lands, and 2) assisting the ADF&G in developing procedures for creating fish and wildlife "element maps" that could serve as fish- and wildlife-oriented land-use alternatives. (In addition, the SCS assessed the economic value of selected fish and wildlife resources, and assisted the ADF&G in evaluating others [USDA 1985].)

In the modeling analyses, Basin habitats were evaluated in terms of: 1) their relative ability to provide food and cover seasonally to selected wildlife species, 2) their relative ability to support a variety of wildlife species ("species diversity"), and 3) their relative abundance within the Basin ("habitat scarcity"). Computer maps were produced displaying the results of each evaluation. Habitats were categorized in terms of plant communities mapped by the USDA (see Table 5), which are described in Resource Statistics for the Susitna River Basin (USDA in preparation).

Following modeling, a methodology was developed to systematically integrate model results, and to combine them with mapped information on wetlands and flood plains. The resultant model synthesis was combined with ADF&G

wildlife population and harvest data to create fish and wildlife "element maps" for use by State planners and others.

Element maps and their accompanying narrative are described immediately below. Following that, SCS fish and wildlife models, steps for integrating model outputs, and procedures for creating fish and wildlife element maps are described. ADF&G and USFWS models are also identified.

B. Fish and Wildlife "Element"

Maintaining the existing diversity and productivity of fish and wildlife populations in the Study Area was identified as a high priority by both the State and Borough during the Susitna River Basin Study (ADNR et al. 1982, ADNR 1982, 1983). As a result, the SCS, USFWS, ADF&G, and ADNR cooperatively examined ways to combine Basin inventory data with existing data to produce products that would help the State and Borough: a) identify and locate particularly important or valuable fish and wildlife habitats in the Study area, b) understand short- and long-term effects of various land uses on selected fish and wildlife populations, habitats, and human uses, and c) develop land-use plans that would specifically consider fish and wildlife resources in the area and would promote their maintenance and enhancement. This cooperative effort resulted in the "fish and wildlife element" used by the Susitna Area Planning (SAP) Team while developing the Matanuska-Susitna Area Plan.

The fish and wildlife element consists of: 1) mylar maps (at scales of either 1:63,360 or 1:250,000 depending on available data) outlining a system of lands that biologists recommend be allocated and managed for fish and wildlife; and 2) supplementary narratives describing the supply of, demand for, and economic contributions of study area fish and wildlife. Three major assumptions are inherent in the element maps and back-up narratives:

Assumption 1: All vegetated Basin lands and many waters currently support fish and wildlife. Existing development pressures suggest that not all of these habitats will be available to fish and wildlife in the future; instead, habitats will decline in quality and quantity as other land and water uses are implemented. As a result, future Basin fish and wildlife will have to be maintained with a smaller habitat base than currently supports them.

Assumption 2: Diverse high-quality fish and wildlife resources can be maintained in the Basin for long-term public benefit, despite development of other resources, if: 1) suitable Basin lands and waters are allocated to and managed for fish and wildlife maintenance and public use, and 2) at the same time, negative environmental impacts of developments occurring outside allocated fish and wildlife areas are mitigated or minimized through land-use guidelines, best management practices, or other appropriate actions.

Assumption 3: Not all areas of the Basin are equally well suited to maintaining Basin fauna and associated human uses. A fish and wildlife

element map, by synthesizing all available information, can help in identifying a system of Basin lands and waters that, if allocated and managed appropriately, will best permit long-term maintenance of fish and wildlife resources most valued in the area.

Element maps themselves provide only an outline of the system of lands and waters identified as essential for maintenance of Basin fish and wildlife. Specific biological values of particular areas are documented instead by: 1) model outputs described below and in Appendix B and C, 2) ADF&G maps of species distributions and of harvest areas, and 3) the element narrative. Site-specific values can, however, be readily determined because element maps are subdivided into individually-numbered "analysis units." Values of each analysis unit are listed in a computer file. Using this file, planners can discover what values are found in an area by looking up appropriate analysis units. Alternatively, all areas (analysis units) having a particular value, such as highly suitable moose winter range, can be listed or mapped by the computer. Appendix B presents an example output from the analysis unit computer file.

In addition to outlining a recommended fish and wildlife system, element maps were also designed to broadly indicate the kinds and intensities of land uses compatible with the fish and wildlife resources found on particular parcels of land. This was done by subdividing identified high-value fish and wildlife lands into four "sensitivity/management" categories, and by outlining recommended land-use practices for each category. Categories were distinguished on the basis of: 1) fish and

wildlife resources supported by specific areas, 2) vulnerability of particular fish and wildlife populations and habitats to disruption from human activities, and 3) options that various areas afford for management and enhancement of fish and wildlife. The four categories used were:

1) "single-use" fish and wildlife lands - recommended for retention in public ownership,

2) multiple-use fish and wildlife lands, conservative management - recommended for retention in public ownership,

3) multiple-use fish and wildlife lands, liberal management - generally recommended for retention in public ownership, but some selected parcels could be made available for land-disposal programs without significant detriment to long-term fish and wildlife resources, and

4) multiple-use fish and wildlife lands particularly suitable for habitat enhancement. (Like (3), these lands were generally recommended for public retention with some exceptions possible.)

A fifth category comprises lands outside the recommended fish and wildlife system. This category encompasses lands and waters where maintenance of fish and wildlife resources is a secondary rather than primary objective. Fish and wildlife resources in these areas can be protected through best management practices, land-use guidelines, and siting and design criteria.

Element maps for Willow, Talkeetna, Beluga, and Upper Susitna Subbasins were developed at a scale of 1:63,360; in the Talkeetna Mountains, Alaska Range, and Glenn Highway areas, fish and wildlife element maps were produced at a scale of 1:250,000. Element maps are on file at the State Department of Natural Resources in Anchorage. Data used in developing element maps are described below and in Appendix B and C.

It will be a challenge to have outlined lands and waters actually allocated for fish and wildlife uses, and a further challenge to have them managed productively and well if they are so allocated. The pressures to use important habitats for settlement, agriculture, hydropower, resource extraction, and other human developments are strong and perpetual. Even if identified lands and waters <u>are</u> allocated to maintain fish and wildlife resources, it is still important for land owners, planners, and managers to take into account the biological truism that "everything is connected to everything else." Wildlife-oriented management of fish and wildlife areas alone will not necessarily ensure long-term maintenance of biological resources currently present. Activities and developments <u>outside</u> fish and wildlife lands can affect animal populations inside the system, as well as those outside it, because all lands are linked by environmental processes such as movements of air, sediments, water, and organisms.

Fish and wildlife managers can generally increase public and political support for protecting lands for fish and wildlife by emphasizing that such lands need not necessarily be single-use areas. If carefully sited,

planned, implemented, and monitored, other resource activities such as forestry and mining are often possible in fish and wildlife habitats without permanent damage to habitats or populations, and may even be used to improve habitat conditions for certain species. With growing pressures to use and develop Alaskan lands, careful multiple-use planning will become increasingly essential.

C. Fish and Wildlife Modeling

1. Introduction

Many of the data collected in the field or from aerial photography during the Susitna Study were used to evaluate land suitability for various uses. In some cases, computer programs (models) were developed by which digitized inventory data could be analyzed and used to create maps showing where known (measured) conditions were favorable or "suitable" for specific land uses such as timber production or farming. In order to do this, optimally suitable conditions were defined (these became "modeling criteria") with which measured conditions in particular areas could be compared. Areas where measured conditions best matched optimum conditions were mapped as most suitable for land uses in question. Because much of the information needed to incorporate fish and wildlife concerns into land use planning was not directly available, suitability of lands for various fish and wildlife resources was also modeled.

Four criteria were used in selecting fish and wildlife resources to be modeled:

1) Where possible, fish and wildlife resources addressed should be positively correlated with overall environmental quality. This criterion led to the modeling and mapping of habitats in terms of their ability to support "high species diversity" and their relative scarcity in the Basin.

2) One or more selected resources should be assessable in economic terms, at least to some degree. This criterion led to the modeling and mapping of habitats in terms of their ability to support the seasonal needs of moose. (Economic analyses of fish and wildlife resources are described in the Susitna River Basin Study USDA summary [USDA 1985].)

3) Resource needs of both "consumptive" human users (e.g. meat and trophy hunters) and "nonconsumptive" users (e.g. photographers, hikers) should be considered. This criterion supported modeling and mapping of habitats associated with high species diversity (generally important for non-consumptive uses) and habitats associated with species harvested by man.

4) Enough data should be available on resources selected to permit them to be adequately modeled. This criterion largely controlled the selection of particular species for habitat suitability modeling.

2. Modeling and Mapping of Species-specific Habitats

Because, for individual fish and wildlife species, all habitats are not created equal, it is possible to identify those habitats on which a particular species generally depends. This is basically a complex task because fish and wildlife often use different habitats during different stages of their lives and seasons of the year, and because their use of particular areas may be based as much on tradition or interactions with other species as on intrinsic environmental conditions. Nonetheless, it is clear that individual species do depend more heavily on certain habitats, where their needs for food, water, shelter, and reproductive environments are most easily satisfied. If conditions distinguishing preferred ("most suitable") habitats can be quantitatively defined, those same conditions can be measured in habitats of interest. Then, by comparing field measurements to defined optima, the relative suitability of measured habitats for species in question can be assessed.

This approach has been formalized by the USFWS in their Habitat Evaluation Procedures (HEP). HEP has been under development since 1974 by the USFWS, with input from other government agencies, universities, and private-sector biologists, and was created to permit documentation of "the quality and quantity of available habitat for selected wildlife species." As developed, HEP can be used to provide information on either: 1) the relative habitat values of different areas at the same point in time; or 2) the relative

value of the same area at future points in time (USFWS 1980a, 1981). Because creating fish and wildlife element maps required both comparing the relative habitat values of different areas in the Basin at the same point in time and projecting future habitat values, HEP provided an appropriate, although still largely unverified, methodology for use in Basin fish and wildlife analyses. Once Basin data had been analyzed with HEP, the SCS also assisted the ADF&G in using inventory data to assess Basin plant communities in terms of their theoretical carrying capacities for moose and their suitability for moose enhancement activities (ADF&G 1984).

Originally, six species were selected for HEP analysis in the Basin: moose, snowshoe hare, willow ptarmigan, spruce grouse, red squirrel, and beaver. These species were selected because: they met needs of both consumptive and non-consumptive human users; "habitat suitability models" were available for each (that is, models defining the optimum habitat conditions for each species) in Terrestrial Habitat Evaluation Criteria Handbook - Alaska (USFWS 1980b); and the relative suitabilities of their Basin habitats could be assessed using digitized river basin data. Where necessary, Handbook models were modified so that available inventory data could be more easily used to assess relative habitat suitabilities.

In the Willow Subbasin, habitat mapping was actually completed for five of the six selected species: moose, snowshoe hare, willow ptarmigan, spruce grouse, and red squirrel. For each of these species, computer maps were

generated showing areas that could theoretically provide highly, moderately, or poorly suitable habitats for "food," "cover," and/or "reproduction." (Computer costs were minimized by depicting two or three species per map.) Details of the Willow Subbasin modeling effort, including suitability criteria and inventory data used, are contained in Appendix C of this report. Published HEP maps are contained in USDA 1981c.

After the Willow Subbasin analysis was completed, modeling efforts were reviewed in light of how modeling products were used by state planners. Three major changes were subsequently made for modeling in the Talkeetna, Upper Susitna, and Beluga Subbasins. The first was to revise and expand moose habitat modeling to reflect additional field data and further discussions with state biologists. To do so, the Willow Subbasin HEP moose model was modified using additional inventory data collected in other subbasins. (The revised moose model is described in Appendix C.) In addition, as mentioned above, the ADF&G used Susitna Basin vegetation data to develop models depicting theoretical moose carrying capacities and moose enhancement potentials of Basin vegetation types. Two additional changes were made in wildlife modeling: 1) plans to repeat Willow Subbasin small game/furbearer models in other subbasins were abandoned, and 2) an alternative methodology was developed for addressing these and other "non-big-game" species.

3. Modeling and Mapping of "High Species Diversity" and "Habitat Scarcity"

a. Introduction

While negotiating allocation of lands in the Willow Subbasin, biologists had seen that maps showing suitable habitats for squirrel, hare, grouse, or ptarmigan were not particularly meaningful to most state planners. Whatever their ecological roles, "non-big-game" species were considered by many state planners to have low economic, political, and aesthetic values. As a result, maps of their preferred habitats had negligible effects on land-use decisions, especially when these habitats appeared relatively abundant at present. Biologists involved with the study were, therefore, faced with how to map and document in a meaningful way habitats supporting these and other non-big-game bird and mammal species.

Three categories of non-big-game habitats were of particular concern to biologists involved with planning. The first consisted of habitats used by a large number, or high diversity, of species. Such areas contribute a disproportionately large percentage to the variety of wildlife species existing in the Basin. The second and third categories consisted of habitats that are "scarce" in the Basin or particularly sensitive to disturbance. It was assumed that species associated with "scarce" or "sensitive" habitats, particularly species highly dependent on them (i.e. "obligate" species), could be disproportionately affected by land-use

changes. For species using "scarce" habitats, few or no alternative sources of food, cover, and reproductive requirements might be available once their habitats were eliminated or altered. For species using "sensitive" habitats, land uses occurring in and outside of their habitats, even at relatively great distances in some cases, might significantly alter required conditions, such as water quality, water flows, nutrient inputs, and sediment regimes. On the assumption that planners would find it useful and meaningful to know which areas supported many kinds of wildlife or relatively scarce habitats (even if most species using these areas would have little weight if considered individually), the SCS developed models to map these two habitat categories. "Sensitive" habitats were later also identified, during the process of assigning management categories to outlined fish and wildlife lands. The models developed to map species diversity and habitat scarcity are described below.

b. Wildlife Species Diversity Model

The goal during development of the wildlife species diversity model was to identify and map plant communities (i.e. habitats) capable of supporting the highest diversity* of wildlife species. Available data on actual wildlife species occurrences in different Basin plant communities were not sufficient

* Here, "diversity" means only the number of different species (often called species "richness"); relative population size of various species is not taken into account.

to identify and map these "high diversity" habitats directly; and available time, personnel, and funding were insufficient to collect these data. As a result, the relative wildlife species diversity characterizing each Basin habitat was indirectly approximated by extrapolating work done by Konkel et al. (1981). (The best available field data on use of Basin habitats by a variety of wildlife species are those compiled by Gipson (1982) and Kessel et al. (1982) as part of the Susitna Hydroelectric Studies.)

Konkel et al. identified wildlife species (birds and mammals) likely to use each mapped habitat (cover type) along the route of the proposed trans-Alaska natural gas pipeline. As explained in their report: "The occurrence and regional distribution of wildlife species within the [gas pipeline] study, and the associations between species and habitat types, were determined through literature research and through consultation with species experts in various government agencies and the academic community... Habitats meeting food, cover, and reproductive needs of a greater number of species [were assumed to] have greater wildlife value. Therefore, diversity of wildlife species within a habitat type [was] emphasized in this evaluation process. Actual species abundance within a habitat type was not a factor in this evaluation. However, it [was] assumed that habitat types with a higher quality rating [in terms of providing a particular species with food, cover, and reproductive needs] would support a higher population [of that species] than habitat types with a lower rating. All species were considered to be of equal importance in this evaluation." (pp. 2,3)

Descriptions of wildlife - habitat associations prepared by Konkel et al. included consideration of: a) which wildlife species used particular habitats, b) when particular habitats would be used by their associated species, c) what "life requisites" (food, cover, reproductive requirements) each habitat provided to associated species, and d) how confident the authors felt about each identified wildlife - habitat association.

In order to apply the findings of Konkel et al. to the Susitna River Basin, cover types used by Konkel et al. (described in Markon 1980) were cross-correlated with cover types mapped in the Susitna Basin. Vegetation types used by Konkel et al. were relatively general (i.e., analogous to Level III Viereck and Dryness 1980), and except in three cases, good equivalents for Basin types were found among gasline plant community descriptions. Correlations between Basin and gasline cover types are shown in Table 11. (In general, data from Region 4 of the gasline corridor [between Delta Junction and the Canadian border] were used whenever possible in making extrapolations because environmental conditions in this area are most similar to those in the Basin, although the "interior" climate of Region 4 is characterized by greater temperature extremes.)

In addition, wildlife species lists compiled by Konkel et al. were compared with species lists compiled for the Basin in order to calculate a

"similarity index"* between the two regions and thus verify that faunas as well as mapped cover types were similar enough in the two study areas to permit extrapolations. As indicated in Tables 12 and 13, mammal species lists were more similar than bird species lists, but both were felt to match well enough to permit extrapolation. For mammals, 42 species were identified by combining lists from both Konkel et al. Region 4 and the Susitna Basin; 81% of these (34 species) occurred in both study areas (Table 12). For birds, 167 species were listed by combining the two areas (Regions 1 and 4 of Konkel et al. were used), 110 of which (66%) were common to both. If bird species using coastal water-related habitats are excluded (that is, shorebirds and waterfowl), agreement between the two study areas increases to 76% (102 species, 77 common to both areas). (Coastal habitats in the Susitna Basin and those found in the gasline corridor were generally dissimilar. As a result, agreements between coastal bird species lists were not as good as agreements between lists of upland birds.) Table 13 shows similarity in bird species lists between the two areas for each Order of birds encountered.

* "Similarity Index" as defined by Samson and Knopf (1982) equals the ratio of species shared by Sample A and B to the total number of species occurring in Sample A plus Sample B.

Table 11. Plant community correlations and wildlife species diversity ratings for SCS vegetation types (after Konkel et al. 1981)

SCS veg. code	High Wildlife Species Diversity (vegetation type)	Konkel et al. veg. code	Markon veg. code
32,34	mixed forest–open	21	14–01
31,33	conifer forest–open	14	12–01
61	tall shrub–riparian willow or mix	8	7–01,7–02
35,36	deciduous forest–open	19	13–01
24,26	mixed forest–closed	22	14–02
62	low shrubs–willow, resin birch	9,10	8–01,8–02, 9–01,9–02
50,51,52	SW wetlands—grass, sedge, shrub	no match	
	Moderate Wildlife Species Diversity		
21,25,41,42	conifer forest–closed	15	12–02
22,27,28,29	deciduous forest–closed	20	13–02
43	short black spruce–open	16	12–03
68,69	sphagnum bog (shrubs)	29	21–00
60	tall shrub alder	no match	
63	grassland	no match	
	Low Wildlife Species Diversity		
70,80,81, 82,83	cultural, mud flat, rock, snow, ice (small agricultural parcels may be included)	12,23,25 (small parcels 24 may be in–cluded)	10–00,16–00, 18–00 (with appropriate qualifiers) (small parcels 17–00 may be included)
	Tundra – Special Consideration		
64,65,66,67	sedge–grass, herbaceous, mat–cushion, and shrub tundra types	1,3,4,5	01–00, 03–00—05–00 (with appropriate qualifiers)
	Water Bodies – Special Consideration		
91,92,96,97	ponds, lakes, streams, rivers		23–00—26–00 (with appropriate qualifiers)

Table 12. Correlation of mammal species lists:

Gasline Corridor – Susitna Basin

Combined species list	Present in Susitna Basin	Present in Both Areas	Present in Gasline–Region 4
1. water shrew	X		
2. arctic shrew	X		
3. singing vole	X		
4. mountain goat	X		
5. masked shrew	X	X	X
6. dusky shrew	X	X	X
7. pygmy shrew	X	X	X
8. little brown bat	X	X	X
9. collared pika	X	X	X
10. snowshoe hare	X	X	X
11. hoary marmot	X	X	X
12. arctic ground squirrel	X	X	X
13. red squirrel	X	X	X
14. northern flying squirrel	X	X	X
15. beaver	X	X	X
16. northern red-backed vole	X	X	X
17. meadow vole	X	X	X
18. tundra vole	X	X	X
19. muskrat	X	X	X
20. brown lemming	X	X	X
21. northern bog lemming	X	X	X
22. meadow jumping mouse	X	X	X
23. porcupine	X	X	X
24. coyote	X	X	X
25. wolf	X	X	X
26. red fox	X	X	X
27. black bear	X	X	X
28. brown bear	X	X	X
29. marten	X	X	X
30. ermine	X	X	X
31. least weasel	X	X	X
32. mink	X	X	X
33. wolverine	X	X	X
34. river otter	X	X	X
35. lynx	X	X	X
36. moose	X	X	X
37. caribou	X	X	X
38. Dall sheep	X	X	X
39. woodchuck			X
40. long-tailed vole			X
41. yellow-cheeked vole			X
42. bison			X
Total number present	38	34	38
Percent of total 42 species	90.5	81.0	90.5

Table 13. Correlation of bird species lists: Gasline Corridor - Susitna Basin

Taxon	Total Number of Species	Number of Species Shared	Percent Agreement
1. Gaviiformes (loons)	3	2	66.7
2. Podicipediformes (grebes)	2	2	100.0
3. Anseriformes (swans, ducks, geese)	29	17	58.6
4. Falconiformes (hawks, falcons, eagles)	13	11	84.6
5. Galliformes (ptarmigan, grouse)	6	4	66.7
6. Gruiformes (cranes)	1	1	100.0
7. Charadriiformes (plovers, sandpipers, phalaropes, jaegers, gulls, terns, murrelets)	36	16	44.4
8. Columbiformes (doves)	1	0	0
9. Strigiformes (owls)	7	6	85.7
10. Coraciiformes (kingfishers)	1	1	100.0
11. Piciformes (woodpeckers)	5	5	100.0
12. Passeriformes (songbirds)	63	45	71.4
Totals	167	110	65.9
(Totals minus Anseriformes and Charadriiformes)	102	77	75.5

Complete correspondence between plant and animal communities identified in the two studies was neither expected nor a prerequisite of the extrapolations performed. The goal in terms of developing a wildlife species diversity model was to ensure that gasline plant and animal communities were similar enough to Susitna Basin communities that Konkel's wildlife/habitat assessments could reasonably be used to provide a relative species-diversity index (rather than a measure of absolute species numbers) for Basin cover types. In other words, it was assumed that if gasline plant communities were generally similar to those in the Basin in terms of plant species, plant community structure, canopy closure, and vertical stratification; and if generally similar bird and mammal faunas occurred in gasline and Basin areas, then the relative wildlife species diversity of mapped Basin plant communities would be approximately equivalent to the relative wildlife species diversity of gasline plant communities.

When an SCS vegetation type was matched by more than one gasline type, it was assigned the highest diversity rating from among the gasline types it matched. Tundra vegetation types were considered separately for two reasons: 1) although tundra types seldom support a large variety of species, they frequently support species rarely found elsewhere (e.g., caribou, Dall sheep, marmot, arctic ground squirrel, etc.); and 2) tundra types tend to be particularly susceptible to disturbance because of the very slow growth rates of plants adapted to these harsh environments—this low

"resilience"* should be considered during planning. Wildlife species diversity ratings assigned to Basin cover types are presented in Table 11.

For the three Susitna Basin cover types not matched by any gasline habitat types, relative wildlife species diversity was rated qualitatively on the basis of general ecological principles. The unmatched Basin estuarine wetlands were rated as having "high wildlife species diversity" because of the seasonally high species diversity, productivity, and ecological importance generally characteristic of these wetlands (see for example, Greeson et al. 1979). "Tall alder shrublands" and "Calamagrostis grasslands" were rated as having "moderate wildlife species diversity" because of the poorly developed vertical stratification and the low structural heterogeneity and plant species diversity of these plant communities. (Grasslands, however, are often characterized by a relatively high diversity and abundance of small herbivorous and insectivorous mammals, e.g., voles, shrews, mice, that in turn provide prey for a variety of bird and mammal predators; and alder shrublands are important soil enrichers because of the nitrogen fixing bacteria associated with alder roots.)

* "resilience" is a measure of the ability of a system to absorb disturbance and persist with the same relationship between components." (Margules and Usher 1981, p. 84)

C. Habitat Scarcity Model

"Habitat scarcity" was considered in an attempt to incorporate a regional perspective in the development of fish and wildlife element maps. As emphasized in a number of recent articles (e.g., Noss 1983, Samson and Knopf 1982), maintaining the fauna native to a region depends largely on maintaining landscape patterns comparable to those existing at the time of human settlement. As Noss points out: "When natural areas are seen as remnant patches interacting with and within a culturally-modified matrix, we are led to consider the diversity of the regional landscape as more significant to conservation than the diversity of any single patch or collection of patches" (p. 12). Similarly, Samson and Knopf identify as the most important issue facing conservationists: "the preservation of a mosaic of habitats in which can be preserved a representative cross-section of native species" (p. 421). To a large extent, Susitna Basin landscapes still reflect conditions and patterns similar to those found at the time of western settlement. By considering habitat scarcity, those habitats among the most likely to be inadvertently lost from this regional pattern, namely those found on the fewest acres, can be highlighted for protection, thus protecting wildlife species they support. A scarcity approach was also in keeping with Jenkins' suggestion that "... the preservation of diversity [of species, communities, natural features, and phenomena] is best accomplished by concentrating on the rarest elements" (1976, p. 448).

Relative scarcity of different habitats (vegetation types) was assessed by first determining how many acres each vegetation type covered, and comparing this acreage to an "equitable" share. The equitable share equaled the acreage or percent-of-subbasin each vegetation type would cover if all types were equally abundant, in other words: total vegetated acres divided by number of vegetation types present. Vegetation-type categories used in calculating equitability were the same 15 categories used in assessing wildlife species diversity (see the previous Section). For example, an "equitable share" in the Talkeetna-Beluga Subbasins* equaled 237,000 acres (3,555,120 acres÷15 vegetation types), or 6.67% of the vegetated area. Each vegetation type was then assigned one of the following four ratings:

1. very scarce: vegetation types covering less than 1.6% of the subbasin under consideration;

2. scarce: vegetation types covering from 1.6% to 4.5% of the subbasin under consideration;

* For this analysis the Talkeetna and Beluga Subbasins were considered as a single unit because of the desire to use a regional perspective when considering vegetation type distributions. These adjacent subbasins are generally similar in terms of latitude, elevations, and relative abundance of mapped cover types.

3. neither scarce nor abundant: vegetation types covering from 4.6% to 8.5% of the subbasin under consideration; and

4. abundant: vegetation types covering over 8.5% of the subbasin.

Table 14 indicates acres and scarcity ratings of vegetation types in the Upper Susitna Subbasin and the combined Talkeetna-Beluga Subbasin. Regional differences between subbasins are readily apparent from Table 14; plant communities abundant in the Talkeetna-Beluga Subbasin are often scarce in the generally higher-elevation Upper Susitna Subbasin, and vice versa. Table 14 also indicates the degree to which one or more vegetation types may dominate an area; for example, over 70% of the vegetated lands in the Talkeetna-Beluga Subbasin support closed mixed forests, sphagnum bogs (with or without shrubs), or tall alder shrublands.* Land planners and users must take into account regional differences in plant community distributions if they wish to maintain or change regional patterns of animal distributions.

* Statistical analysis of data collected within each vegetation type would indicate whether these very abundant types contain more heterogeneity than other types used in wildlife modeling (Resource Statistics for the Susitna River Basin, USDA in progress).

Table 14. Habitat Scarcity Ratings

Vegetation Type	SCS Codes	Total % of Talkeetna plus Beluga veg. area	Total acres of veg. type in Talkeetna-Beluga Subbasin	Vegetation scarcity/ abundance rating	Total % of Upper Susitna vegetated area	Total acres of veg. type in Upper Susitna Subbasin	Vegetation scarcity/ abundance rating of veg. type
OPEN MIXED FOREST	32,34	6.01	213,570	neither scarce nor abundant	0.61	11,600	very scarce
OPEN CONIFER FOREST	31,33	2.03	72,280	scarce	1.08	20,400	very scarce
TALL SHRUB ALDER-WILLOW (RIPARIAN)	61	5.50	195,700	neither scarce nor abundant	1.09	20,680	very scarce
OPEN DECIDUOUS FOREST (COTTONWOOD)	35,36	0.21	7,510	very scarce	*	*	*
CLOSED MIXED FOREST	24,26	23.40	831,810	abundant	2.00	37,720	scarce
LOW SHRUBS-WILLOW, RESIN BIRCH	62	0.83	29,530	very scarce	5.61	105,920	neither scarce nor abundant
SALTWATER WETLANDS-GRASSLAND, SEDGE MARSH	50,52	0.73	26,020	very scarce	0	0	N/A
CLOSED CONIFER FOREST	21,25, 41,42	5.72	203,260	neither scarce nor abundant	0.91	17,240	very scarce
LOW SHRUB SALT-WATER WETLAND	51	0.12	4,300	very scarce	0	0	N/A
CLOSED DECIDUOUS FOREST	22,27,28,29	0.54	19,030	very scarce	0.14	2,720	very scarce
OPEN SHORT BLACK SPRUCE FOREST	43	0.23	8,150	very scarce	0.29	5,400	very scarce
SPHAGNUM BOG, WITH AND WITHOUT SHRUBS	68,69	20.76	738,070	abundant			
TALL SHRUB ALDER	60	25.95	922,700	abundant	18.12	342,440	abundant
GRASSLAND (CALAMAGROSTIS)	63	1.54	54,780	very scarce	0.06	1,120	very scarce
TUNDRA	64,65, 66,67	6.42	228,410	neither scarce nor abundant	58.58	1,106,960	abundant
TOTAL VEGETATED ACRES IN SUBBASIN			3,555,120			1,672,200	
P non-vegetated	70,80, 81,82,83	NA	80,730	2.14% of total area	N/A	209,240	11.07% of total area
Water lakes and streams	91,92, 96,97	NA	133,820	3.55% of total area	N/A	8,280	0.44% of total area
TOTAL ACRES			3,769,670			1,889,720	

* Minimum mapping unit in Upper Susitna Subbasin was 40 acres (rather than 10 acres as in other mapped subbasins). As a result, plant communities that occur only in small parcels (polygons) are not delineated.

4. Integration of Model Outputs

a. Introduction

Once individual models were completed, a "habitat synthesis" model was developed. The goal was to create a model that could use computerized inventory data to design a first approximation of a fish and wildlife element map. To do this, steps were first outlined for computer integration of the models described above. Additional steps were then added to include consideration of wetlands, flood plains, and riparian corridors. Further development of the fish and wildlife element map involved "fleshing out" the computer-generated skeleton by manually adding important habitat areas identified by ADF&G biologists but not included in the automated data base. Modeling steps involved in generating the synthesis-map are described below and outlined in Table 15.

As shown in Table 15, the "synthesis" model (excluding stream and river corridors and wetlands) covered approximately 18.4% of the combined Talkeetna-Beluga Subbasins and 11.8% of the Upper Susitna Subbasin. Within these relatively small subsets of subbasin lands, <u>all</u> vegetation types that are not "abundant" are specifically addressed, vegetation types supporting the greatest variety of species are specifically addressed, and year-round moose range is addressed (both directly or indirectly). Additional acreages, not shown in totals, add "abundant" vegetation types where they

occur in proximity to river and stream corridors, along with wetlands and flood plains. The steps in the synthesis model are simple and easily replicated. It was hoped that these features of the model output would help make the land and water system it identified readily explainable and meaningful to planners as high value for fish and wildlife. Manual addition of other high value fish and wildlife lands is described following outline of synthesis model steps.

b. Habitat Synthesis Model Steps

Step 1: Using one pattern or shade, print all "high wildlife diversity" vegetation types that are "very scarce" or "scarce" and all "moderate wildlife diversity" vegetation types that are "very scarce" in each subbasin. (The area identified by this step covers approximately 6.2% of the combined Talkeetna-Beluga Subbasins and 6.2% of the Upper Susitna Subbasin.)

Step 2: Using a second pattern or shade, print "open mixed forests" and "tall shrub, alder-willow (riparian)" vegetation types if not printed during step 1 and if not "abundant."* These two vegetation types are identified as

* If these vegetation types are "abundant," selection of representative acreages of these types must be made manually. See following Section for description of manual mapping procedures.

Table 15. Summary of instructions for habitat synthesis model

	Instructions for each step	SCS vegetation codes included by each step		Total acres (% of vegetated acres)* in Subbasin included by each step	
		Talkeetna-Beluga Subbasin	Upper Susitna Subbasin	Talkeetna-Beluga Subbasin	Upper Susitna Subbasin
Step 1:	map all "very scarce" and "scarce" habitats having "high species diversity" plus all "very scarce" habitats having "moderate species diversity"	31, 33, 35, 36, 50, 51, 52, 62; 22, 27, 28, 29, 43, 51, 63	24, 26, 31, 32, 33, 34, 61; 21, 22, 25, 27, 28, 29, 41, 42, 43, 63, 68, 69	225,784 (6.35%)	103,342 (6.18%)
Step 2:	map all "open mixed forests" and "tall alder willow riparian shrublands" if not previously mapped and if not "abundant"	32, 34, 61	included by step 1	409,194 (11.51%)	included by step 1
Step 3:	map stream and river corridors	stream corridor portions of 21, 24, 25, 26, 41, 42, 60, 64, 65, 66, 67, 68, 69	stream corridor portions of 60, 64, 65, 66, 67	not computer mapped, (not computed)	not computer mapped, (not computed)
Step 4:	map all "shrub tundra" and "low shrub willow-resin birch" if not previously mapped and if not "abundant"	66	62, 66	17,470 (0.49%)	93,810 (5.61%)
Step 5:	map selected freshwater wetlands not yet mapped	SCS wetland codes 2, 3, 6**	SCS wetland codes 2, 3, 6**	not computer mapped, (not computed)	not computer mapped, (not computed)
	Totals			652,448 (18.35%)	197,152 (11.79%)

* 94.3% of the Talkeetna Beluga Subbasin is vegetated,
88.5% of the Upper Susitna Subbasin is vegetated.

** SCS wetland types are described in USDA in progress and briefly in this text.

among those with the "highest wildlife species diversity." (The area identified by this step covers approximately 11.5% of the combined Talkeetna-Beluga Subbasins. These two vegetation types are "very scarce" in the Upper Susitna Subbasin and were, therefore, mapped by step 1.)

Step 3: Using a third pattern or shade, print recommended stream corridors.* This step was approximated manually in the Talkeetna, Beluga, and Upper Susitna Subbasins because stream data, as incorporated in the digitized data base, did not allow computer performance of this step. Corridor widths recommended along individual streams roughly reflected stream drainage areas. Table 16 identifies corridor widths recommended on the basis of drainage areas.

Step 4: Using a fourth pattern or shade, print all areas supporting either "low shrubs-willow, resin birch" or "shrub tundra" vegetation types if these

* Values of riparian corridors to fish and wildlife and to human recreationists are well documented. (See, for example, Thomas 1979, ADF&G 1983c, USDA 1983.) In addition, human developments along streams and rivers are often subject to flood damage and destruction. Incorporating stream and river corridors into the recommended system of fish and wildlife lands was considered of highest priority by all biologists involved in the Susitna study.

types are not "abundant" and were not printed during steps 1 or 3.* Most areas of moderately or highly suitable moose winter range were mapped as byproducts of steps 1, 2, and 3. As a result, moose winter range did not need to be specifically addressed in the synthesis model. Important moose spring/summer/fall range, however, was not necessarily adequately mapped during the first three steps; step 4 resulted in inclusion of areas providing suitable moose spring/summer/fall range. (The area identified by this step covers approximately 0.5% of the combined Talkeetna-Beluga Subbasin and 5.6% of the Upper Susitna Subbasin.)

Step 5: Using a fifth pattern or shade, map freshwater wetlands not yet mapped and that are identified by the following SCS codes in the Basin wetland model: 2, 3, and 6.** Saltwater wetlands were mapped by step 1; this step incorporated freshwater wetlands other than "black spruce forests

* If these vegetation types are "abundant," selection of representative acreages of these types must be made manually. See following Section for description of manual mapping procedures.

** The wetland model is described in USDA 1985. Codes included here represent the following wetland plant communities: 2 = cottonwood forests and woodlands, 3 = mixed deciduous-coniferous forests and woodlands, 6 = freshwater marshes.

Table 16. Recommended fish and wildlife/public use corridor widths for Susitna Basin streams

Drainage Area 1/	Recommended width for fish and wildlife/ public use corridor 2/	Examples 3/
over 500,000 acres	1 mile from each bank	Susitna River, Yentna River, Kahiltna River, Talkeetna River, Skwentna River, Chakachatna River, Beluga River
150,000 to 500,000 acres	3/4 mile from each bank	Kroto Creek, Kichatna River, Talachulitna River, McArthur River, Kashwitna River, Little Susitna River, Chulitna River
75,000 to 150,000 acres	1/2 mile from each bank	Montana Creek, Little Willow Creek, Moose Creek, Johnson Creek, Kustatan River, Chuitna River, Sheep Creek, Theodore River

1/ Drainage areas were obtained from Susitna Basin Flood Plain Management and Flood Hazard Studies (USDA 1981, 1982).

2/ Corridor widths as measured outward perpendicular from each stream bank.

3/ Streams are listed in order of decreasing drainage area. All streams not followed by an (*) are important for spawning, rearing, or migration of anadromous fishes (ADF&G 1983a). All streams followed by an (*) are not listed in ADF&G 1983a.

Table 16. Recommended fish and wildlife/public use corridor widths for Susitna Basin streams (continued)

Drainage Area 1/	Recommended width for fish and wildlife/ public use corridor 2/	Examples 3/
10,000 to 75,000 acres	1/4 mile from each bank	Donkey Creek, Fourth of July Creek*, Peters Creek, Nikolai Creek, Honolulu Creek, Lewis River, Ivan River, Byers Creek, Red Creek, Wasilla Creek, Cottonwood Creek, Troublesome Creek, Nakochna River, Rabideux Creek, 196 Mile Creek*, Old Tyonek Creek, Ninemile Creek*, Threemile Creek, Answer Creek, Birch Creek*, Trapper Creek, Gate Creek, Tyonek Creek, Goose Creek, Chuitkilnachna Creek*, Twentymile Creek, Caswell Creek
less than 10,000 acres	standard minimum corridor as determined by ADF&G and ADNR; or, in cases of special or unique values, corridor determined on a case-by-case basis	Lucile Creek, Olson Creek, Seventeenmile Creek

* All streams not followed by an (*) are important for spawning, rearing, or migration of anadromous fishes (ADF&G 1983a). All streams followed by an (*) are not listed in ADF&G 1983a.

and muskegs" (SCS wetland code 1) or "sphagnum bogs with or without shrubs" (SCS wetland codes 4, 5). Muskegs and bogs are either "very scarce" and mapped by step 1, or "abundant" and considered adequately addressed by step 3. (This step was performed by manual map overlay, actual acreages covered are, therefore, not computed. In actuality, most of these freshwater wetlands were incorporated by previous steps.)

D. Creating the Fish and Wildlife Element Map

As mentioned previously, fish and wildlife element maps constitute a land-use alternative designed to maintain Basin fish and wildlife resources. Element maps were developed using the various model outputs discussed above in combination with available ADF&G data. ADF&G data consisted of: 1) maps at various scales displaying distributions and ranges of particular species or species groups; namely salmon (and some other anadromous and resident fishes), moose, caribou, Dall sheep, black bear, brown bear, furbearers, waterfowl, seabirds, and raptors; 2) maps displaying known "essential use areas," such as Dall sheep salt licks, moose or caribou calving grounds, trumpeter swan nesting lakes, bear denning sites; 3) maps and data indicating where particular species are harvested; and 4) general data from field biologists on where particular species are likely to be found. ADF&G data on Basin resources are contained in the narrative fish and wildlife element and its accompanying atlas (ADF&G 1984). Appendix B lists ADF&G maps used during the study.

The actual element maps were drafted manually on a sheet of mylar. "Core" areas were outlined first on the mylar sheet. These consisted of: 1) lands identified by the habitat synthesis model, namely, riparian corridors, habitats supporting many kinds of wildlife, scarce habitats, habitats supporting highly suitable moose range, and selected wetlands; and 2) known "essential use areas" identified by the ADF&G.

Once core areas had been mapped, connecting these lands via ecological corridors became the next priority. There were seven main reasons why interconnecting core areas was considered essential. To begin with, connecting the skeletal core system of fish and wildlife lands was a logical way to increase its size. Size of wildlife area has been identified by many researchers as an important determinant of which and how many wildlife species can be maintained (e.g., Diamond et al. 1976, Diamond and May 1976, Sullivan and Shaffer 1975, MacArthur and Wilson 1967). Up to a point, increased area is positively correlated with increased species diversity. Whitcomb et al. (1976) provide the following summary of reasons for maximizing the size of fish and wildlife management areas:

a) Larger areas can support a greater number of wildlife species; one rough rule is that a tenfold increase in area size corresponds to a doubling of the equilibrium number of species present (the number of species reaches "equilibrium" when immigration of new species equals extirpation of species already present);

b) Large areas generally have higher species immigration rates and lower extinction rates than comparable smaller areas (this is a corollary of (a) above);

c) Some species require very large home ranges. For example, species using seasonally or spatially patchy food supplies, such as moose and bear, must use resources distributed over a large area; large carnivores, such as wolves and wolverines, must range over a large area to obtain sufficient prey. Maintaining these species consequently requires maintaining large areas of appropriate habitat.

d) Preservation of entire ecological communities, with all trophic levels represented, generally requires large areas;

e) Large fish and wildlife management areas are better buffered against human perturbations and natural disasters;

f) Large areas are often necessary to minimize the pressures of predation, parasitism, and competition exerted by species abundant in disturbed areas surrounding wildlife lands;

g) Failures of small wildlife areas to maintain all species initially present have been amply documented;

h) The irreversibility of habitat fragmentation demands a conservative strategy in protecting fish and wildlife lands and waters.

A second reason for interconnecting core areas was based on evidence that even small habitat "islands" can support both wide-ranging species and much of their indigenous fauna if they are ecologically connected to, and "subsidized" by, larger habitat areas (MacClintock et al. 1977). Habitat corridors through disturbed lands allow replacement populations to travel from larger areas (where the species can persist) to smaller parcels.* The importance of interconnecting habitat "patches" is also emphasized by Noss (1983).

Thirdly, although core areas have been identified as especially suitable for fish and wildlife resources emphasized during this study, all undisturbed vegetated lands in the Basin provide good to excellent habitats for particular species. Connecting and filling out the core skeleton with contiguous areas incorporated additional habitats that could satisfy the life requirements of many "non-target" wildlife species.

* An example of the effectiveness of such habitat corridors in "subsidizing" habitat "islands" is illustrated in Anchorage. Moose are often seen in subdivisions well within the city limits, such as Rogers Park, Lake Otis Park, and Turnagain, because these areas are connected by greenbelt corridors to large habitat areas, such as Ft. Richardson and Chugach State Park.

Fourthly, many highly valued big game species in the Basin move between different habitats at different times of year. Moose, for example, use upland shrubs during spring, summer, and fall, but migrate to riparian corridors as snow depths increase in upland areas. Corridors connecting areas can serve as migration routes for species that seasonally move from one area to another.

Fifthly, the suitability of lands for recreationists interested in enjoying fish and wildlife resources can be enhanced by dispersing recreational users, and by providing opportunities for extended hiking, boating, hunting trips, etc. in natural settings that are uninterrupted by incongruous land uses. A widespread system of interconnected habitat/recreation lands and waters promotes user dispersion and permits extended high quality recreational outings.

Sixth, an interconnected system is generally easier to manage than a fragmented system. Some habitat management techniques, such as prescribed fires, are not feasible or economical on fragmented parcels.

Seventh, current understanding of many natural ecosystems is still rudimentary. A diverse, extensive, interconnected system of suitable fish and wildlife lands and waters, particularly a system in which all habitats in the Basin are adequately represented, was viewed as a logical means to encompass most of the ecological conditions and processes that maintain fish

and wildlife habitats and populations, despite current inability to identify and account for all such ecosystem components.

An eighth, but essentially "political," reason exists for tying core areas together in an interconnected system. An interconnected system provides a spatial context for the inclusion of any particular parcel. As a result, lands can be recommended for wildlife-related allocations not only on the basis of their inherent values (which may cease to be meaningful to planners if repeated for parcel after parcel) but also on the basis of the physiographic and biological linkages that they provide between parts of the overall system. Because the functional unity of an interconnected system can be graphically seen, the need for parcel-by-parcel justification of recommended lands should theoretically be reduced. Thillmann and Monasch (1976) point out that with a logical integrated system: "Dedications of land can be evaluated within the context of a pattern that responds to the natural determinism of the landscape ..." and as a result "... the development industry can see that a unique and valuable open space resource combining many elements can be of prime importance ... [to] development and [that] ... [open space] areas are not arbitrary, capricious, or unreasonable." They further note that they were "... extremely successful in eliciting contributions of the EQC'S [Environmental Quality Corridors that form the framework of their open-space system] wherever they affect land which is up for rezoning." (pp. 552-553.) Since "sale-ability" of fish and wildlife land-use alternatives will certainly in part determine the

acreage allocated to fish and wildlife resources, recommending an interconnected system of lands and waters appears to have practical, as well as ecological, values.

Core areas were interconnected and expanded by laying the mylar sheet over various models and maps and "fleshing out" the system with contiguous or nearby areas of additional moose range (identified by the HEP moose model and ADF&G biologists), additional "abundant" vegetation types and wetlands, and areas of high human use. Wherever possible, edges* between plant communities, and areas of high vegetative interspersion* were incorporated when connecting or expanding core areas. Finally, the outlined system was examined to ensure that all types of vegetation, wetlands, landforms, and water bodies inventoried in the Basin were represented. ADF&G field and area biologists then reviewed element maps to identify any additional essential use areas, hunter access points, etc. warranting inclusion.

As mentioned above, the goal during this process was to outline a fish and wildlife land base that was, in essence, greater than the sum of its parts. In other words, although the system initially grew around lands highly

* Although not used here, approaches exist for automatically mapping and calculating edge, interspersion, juxtaposition and other wildlife-related spatial patterns using geographic information systems (see, for example, Heinen and Cross 1983, Brooks and Scott 1983).

suitable for a few selected fish and wildlife resources, it was believed that the diversified pattern of lands produced by spreading outwards from and interconnecting core areas would encompass a full spectrum of environmental conditions, processes, and interrelationships, and hence would support a full complement of Basin fish and wildlife resources.

V. Fish and Wildlife Field Investigations

In order to facilitate the kinds of modeling described above, it was important that the SCS and FS collect environmental data that could be used to assess the value of Basin habitats for particular wildlife species. In general, two types of data are needed to make such assessments: 1) data on which animal populations are present in particular areas, in what numbers and when, and 2) data on environmental conditions present in particular areas at different times of year (specifically, conditions affecting the presence and abundance of wildlife populations of interest). When cross-correlated, population data and environmental data can generally identify habitats in which particular species are most likely to be found. Such analyses can be used to assure that habitats supporting desirable wildlife species are maintained, or that conditions in managed habitats are favorable to particular species.

Collecting data on fish and wildlife populations, for example, population size, distribution, seasonal movements, birth and death rates, etc., is the responsibility of the ADF&G and the USFWS. The SCS, on the other hand, collects or assists with collection of data on environmental conditions such as soil characteristics; plant species, cover, and productivity in particular areas; quality and quantity of local or regional water resources; and types of landforms present. These kinds of data can be very useful in describing and characterizing specific habitats where, according to ADF&G or

USFWS data, particular species do occur. Once associations between species and habitats have been described, "potential" habitats can be identified in areas where appropriate environmental data exist, even if population data are lacking. (This is the principal rationale behind species-specific models discussed above.)

In order to make sure that environmental data collected during the Susitna Study would be useful when evaluating habitats for selected wildlife species, the SCS sought assistance from the USFWS and the ADF&G in identifying meaningful "habitat parameters" to inventory. Habitat parameters consist of specific measurable environmental characteristics that appear to be correlated to the suitability of a habitat for a particular species. For moose, for example, parameters that affect how well a habitat provides necessary food and cover include:

a) total available browse, measured in pounds per acre;

b) availability of browse species preferred by moose, such as willow (Salix spp.) and birch (Betula spp.), measured as a percent of total available browse;

c) amount of cover available, measured as percent of surface area covered by tree or tall shrub foliage; and

d) total annual forb production, measured in pounds per acre.

Moose habitat parameters and parameters relevant to other species had originally been identified as part of the "Habitat Evaluation Procedures" (HEP) developed by the USFWS. The SCS was able to incorporate measurement of HEP parameters into its field activities, and hoped thereby to collect environmental data of greatest possible use to wildlife biologists. Examples of habitat characteristics measured during collection of field data, and of wildlife signs noted during surveys, are provided in Appendix D.

In addition to HEP parameters, many inventory data not specifically collected for wildlife analyses have been used for habitat models discussed above, particularly vegetation data. The ADF&G is planning a new examination of SCS vegetation data as part of a "habitat suitability assessment" in which actual moose distribution data will be correlated with mapped and inventoried plant community data in a portion of the Talkeetna Subbasin (Shea et al. 1983). Further use of River Basin products for similar analyses is encouraged whenever time and funding permit. Through such analyses, both modeling and field data collection can be improved.

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(References marked with an (*) contain discussions particularly relevant to the evaluation, selection, and/or design of "conservation" lands and systems.)

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Appendixes to:

Identifying Wildlife Lands: Fish and Wildlife Analyses

for the Susitna River Basin Study

USDA 1985

APPENDIX A

Bibliography of reports prepared during the Susitna River Basin Study

Prepared by or for the USDA:

(Those marked with an * are contained in full in: Susitna River Basin Study Summary of USDA Investigations and Analyses [USDA SCS, 1985])

Economics:

1. The Susitna Cooperative River Basin Study Economic Development Analysis (P. Fuglestad and J. O'Neill, 1983, USDA ERS, SCS)

2. * A Methodology for Estimating Road Costs in the Susitna River Basin (P. Fuglestad and J. O'Neill, 1983, USDA ERS, SCS)

Water Resources:

1. * Mean Annual Precipitation and Water Yield in the Susitna River Basin (E. Merrell, 1979, USDA SCS)

2. Susitna Basin Planning Background Report – Water Supply and Demand (B. Loeffler, 1980, ADNR in cooperation with USDA)

3. Susitna Basin Water Quality Report (B. Rummell, no date, for USDA SCS, FS, ERS)

Soils:

1. Soil Survey – Susitna East Area, Alaska (USDA SCS, in progress)

2. Soil Survey – Yenta Area, Alaska (USDA SCS, in progress)

Land Treatment and Agronomy:

1. Alaska Irrigation Guide (E. Merrell, in progress, USDA SCS)

Geology:

1. Geology Report for the Talkeetna Subbasin, Susitna River Basin Alaska Cooperative Study (S. Sumsion, 1979, unpublished report prepared for the USDA SCS)

Land Cover (Vegetation):

1. Preliminary Field Procedures for the Cooperative Vegetation Inventory of the Susitna River Basin, Alaska (USDA FS, PNW, 1979)

2. Resource Statistics for the Susitna River Basin (USDA SCS, FS, ERS, in progress)

3. Timber Resource Statistics for the Talkeetna Block, Susitna River Basin Multiresource Inventory Unit, Alaska (T. Setzer, G. L. Carroll, B. R. Mead, 1979, USDA FS, PNW Forest and Range Experiment Station)

Recreation:

1. Recreation Atlas - Willow-Talkeetna Basin (ADNR in cooperation with USDA, 1979)

Archeological, Historical, and Cultural Resources:

1. Cultural Resource Assessment: Talkeetna-Lower Susitna River Basin, Southcentral Alaska (G. Bacon, J. Kari, and T. Cole, 1982, for USDA SCS, FS, ERS)

2. Cultural Resource Assessment: Talkeetna-Lower Susitna River Basin, Southcentral Alaska (supplemental report) (G. Bacon and T. Cole, 1982, for USDA SCS, FS, ERS)

3. Cultural Resource Assessment: Beluga Study Area, Southcentral Alaska (G. Bacon, J. Kari, T. Cole, C. Mobley, and R. Carlson, for USDA SCS, FS, ERS)

Fish and Wildlife and Wetlands:

1. Identifying Wildlife Lands: Fish and Wildlife Analyses for the Susitna River Basin Study (D. Lehner, 1984, USDA SCS)

2. * Wetlands Mapping in the Susitna River Basin (USDA SCS, FS, ERS, 1985)

Flood Plain Management:

1. Flood Hazard Study, 196 Mile, Caswell, Sheep, Goose, Montana, Answer, and Birch Creeks and Tributaries (E. Grey, 1981, USDA SCS, ERS, FS)

2. Flood Plain Management Study, Beluga Streams (E. Grey, 1982, USDA SCS, ERS, FS)

3. Flood Plain Management Study, Kashwitna River; Wasilla, Cottonwood, and Lucile Creeks (E. Grey, 1982, USDA SCS, ERS, FS)

4. Flood Hazard Study, Kroto, Rabideux, Trapper, and Peters Creek (E. Grey, 1982, USDA SCS, ERS, FS)

5. Flood Hazard Study, Troublesome, Byers, and Honolulu Creeks; East and Middle Forks of the Chulitna (E. Grey, 1981, USDA SCS, ERS, FS)

Data Processing (Geographic Information Systems):

1. Final Report: Computerized Geographic Information System - Talkeetna and Beluga Subbasins, Susitna River Basin, Alaska (ESRI, 1982, for USDA SCS, FS)

2. Final Report: Computerized Geographic Information System - Upper Susitna Subbasin (ESRI, 1983, for USDA SCS, FS)

Bibliographies:

1. Susitna River Basin Resource Bibliography (ADNR in cooperation with USDA, 1977)

2. Susitna River Basin Resource Bibliography, supplement 1979 (D. Lockhart, 1979, ADNR in cooperation with USDA SCS, FS, ERS)

Prepared by other agencies with USDA assistance:

1. Land Status Atlas - Susitna River Basin (Alaska Department of Natural Resources, 1978)

2. Land Use Issues and Preliminary Resource Inventory (volume 1 of 2) Growth Potential, Development Issues, Settlement Patterns (volume 2 of 2) (Alaska Department of Natural Resources, in cooperation with the Matanuska-Susitna Borough, Alaska Department of Fish and Game, Alaska Department of Transportation and Public Facilities, Kenai Peninsula Borough, and USDA, 1982)

3. Matanuska-Susitna Borough Comprehensive Plan (Matanuska-Susitna Borough)

4. Resource Elements (Department of Natural Resources, 1984)

   a. Agriculture Element for the Susitna Area Plan

b. Fish and Wildlife Resources Element for the Susitna Area Plan (Alaska Department of Fish and Game)

c. Forestry Element for the Susitna Area Plan

d. Settlement Element for the Susitna Area Plan

e. Recreation Element for the Susitna Area Plan

f. Subsurface Resources Element for the Susitna Area Plan

5. Response to Public Comments on the Draft Susitna Area Plan (Alaska Department of Natural Resources, 1985)

6. Susitna Area Plan (Public Review Draft) (Alaska Department of Natural Resources, in cooperation with the Matanuska-Susitna Borough, Alaska Department of Fish and Game, Alaska Department of Transportation and Public Facilities, Kenai Peninsula Borough, USDA, and BLM, 1984)

7. Susitna Area Plan (Final Draft) (Alaska Department of Natural Resources, in cooperation with the Matanuska-Susitna Borough, Alaska Department of Fish and Game, Alaska Department of Transportation and Public Facilities, Kenai Peninsula Borough, USDA, and BLM, 1985)

8. Susitna Area Plan Land Use Alternatives (Alaska Department of Natural Resources, 1983)

9. Susitna Area Plan, Public Workshops Spring 1983, Summary of Results and Staff Analysis (Alaska Department of Natural Resources, Resource Allocation Section, Division of Land and Water Management, 1983)

10. A Synthesis and Evaluation of ADF&G Fish and Wildlife Resources Information for the Willow and Talkeetna Subbasins (Alaska Department of Fish and Game, 1983)

Appendix B:

Outline of Susitna Basin Data Base

maintained by the Alaska Department of Fish and Game

1) Example computer printout of Analysis Unit Data (Analysis Unit 1149)

2) List of maps compiled in ADF&G Susitna Area Plan Fish and Wildlife Atlas (ADF&G 1984)

SUSITNA AREA PLANNING
HABITAT RATING BY ANALYSIS UNIT JUNE 1983
UNIT # 1149 TOTAL= 2400 DNR TOTALS= 2410

ANALYSIS UNIT	MODEL NAME	MODEL CATEGORIES	NO. OF ACRES	PERCENT OF TOTAL ALL CATS	PERCENT OF TOTAL (3,2,1)	MODEL RATING
1149	MOOSE ECAP.SUM/WIN					2.0
		3=HIGH	1030	45.0	45.4	
		2=MEDIUM	560	23.3	25.5	
		1=LOW	740	30.8	31.1	
		0=NONE	0	.0		
		-1=UNKNOWN	20	.8		
1149	MOOSE PCAP.SUM/WIN					3.0
		3=HIGH	1640	68.3	76.6	
		2=MEDIUM	0	.0	.0	
		1=LOW	500	20.8	23.4	
		0=NONE	240	10.0		
		-1=UNKNOWN	20	.8		
1149	MOOSE ENH.VEGETATION					1.0
		3=HIGH	0	.0	.0	
		2=MEDIUM	90	3.8	5.5	
		1=LOW	1550	64.6	94.5	
		0=NONE	760	31.7		
		-1=UNKNOWN	0	.0		
1149	MOOSE HAB.OTHER SEASONS					2.0
		3=HIGH	1080	45.0	45.8	
		2=MEDIUM	1080	45.0	45.8	
		1=LOW	200	8.3	8.5	
		0=NONE	0	.0		
		-1=UNKNOWN	40	1.7		
1149	MOOSE HAB.WINTER					3.0
		3=HIGH	1080	45.0	57.4	
		2=MEDIUM	800	33.3	42.6	
		1=LOW	0	.0	.0	
		0=NONE	500	20.8		
		-1=UNKNOWN	20	.8		
1149	SPECIES DIVERSITY					2.0
		3=HIGH	90	3.8	3.8	
		2=MEDIUM	2310	96.3	96.3	
		1=LOW	0	.0	.0	
		0=NONE	0	.0		
		-1=UNKNOWN	0	.0		
1149	HAB.SYNTHESIS					
		0=OTHER	2020	84.2		
		1=STREAMS	290	12.1		
		2=SCARCE MOD/HIGH DIV	0	.0		
		3=OPEN CANOPY	90	3.8		
		4=SHRUB TUNDRA	0	.0		
1149	AGRICULTURE					
		1=UNSUITABLE	540	22.4		
		2=CLASS I SOILS	0	.0		
		3=CLASS II SOILS	290	12.0		
		4=CLASS III SOILS	1460	60.6		
		5=CLASS IV SOILS	120	5.0		
1149	GRAZING					
		1=NONE	1890	78.4		
		2=HIGH	0	.0		
		3=MODERATE	0	.0		
		4=LOW	470	19.5		
		5=WATER	50	2.1		
1149	FORESTRY					
		1=NO VALUE	0	.0		
		2=HIGH	1660	68.9		
		3=MODERATE	140	5.8		
		4=LOW	90	3.7		
		5=VERY LOW	470	19.5		
		6=NON-FOREST	0	.0		
		7=WATER	50	2.1		
1149	SETTLEMENT					
		1=WATER	50	2.1		
		2=VERY LOW	720	29.9		
		3=LOW	50	2.1		
		4=MODERATE	560	23.2		
		5=HIGH	1030	42.7		

VEGETATION TYPES BY ANALYSIS UNIT
UNIT # 1149 TOTAL= 2400

TYPE	ACRES	%
CLOSED FOREST	1550	64.6
21=CONIF/MS/SHORT	0	.0
22=DECID/MX/YNG	0	.0
24=DECID/MX/MED	990	41.2
25=CONIF/MS/TALL	0	.0
26=DECID/MX/OLD	560	23.3
27=COTTONWOOD/YNG	0	.0
28=COTTONWOOD/MED	0	.0
29=COTTONWOOD/OLD	0	.0
OPEN FOREST-WOODLAND	0	.0
31=CONIF/MS/SHORT	0	.0
32=DECID/MX/MED	0	.0
33=CONIF/MS/TALL	0	.0
34=DECID/MX/OLD	0	.0
35=COTTONWOOD/MED	0	.0
36=COTTONWOOD/OLD	0	.0
CLOSED FOREST (BS-MH)	240	10.0
41=BLK SPRUCE/SHORT	240	10.0
42=BLK SPRUCE/TALL	0	.0
45=MT HEMLOCK/SHORT	0	.0
46=MT HEMLOCK/TALL	0	.0
OPEN FRST-WOOD (BK SP)	0	.0
43=BLK SPRUCE/SHORT	0	.0
SALT WATER WETLANDS	0	.0
50=SALT GRASSLAND	0	.0
51=LOW SHRUB	0	.0
52=TIDAL MARSH	0	.0
TALL SHRUBS	90	3.8
60=ALDER	0	.0
61=ALDER-WILLOW	90	3.8

TYPE	ACRES	%
LOW SHRUB	0	.0
62=WILLOW R. BIRCH	0	.0
GRASSLAND	0	.0
63=UPLAND GRASS	0	.0
TUNDRA	0	.0
64=SEDGE-GRASS	0	.0
65=HERBACEOUS	0	.0
66=SHRUB	0	.0
67=MAT & CUSHION	0	.0
FRESHWATER WETLANDS	500	20.8
68=SPHAGNUM BOG	0	.0
69=SPHAG-SHRUB BOG	500	20.8
CULTURAL FEATURES	0	.0
70=CULTURAL INFLNCS	0	.0
BARREN	0	.0
80=MUD FLATS	0	.0
81=ROCK	0	.0
PERMANENT SNOW & ICE	0	.0
82=SNOWFIELD	0	.0
83=GLACIER	0	.0
WATER	20	.8
91=LAKES GT 40 AC	20	.8
92=LAKES GT 10 LT 40	0	.0
96=STREAMS & RIVERS	0	.0
97=RIVERS GT 1/8 MI	0	.0

TYPE	ACRES	%
WHITE SPRUCE (21,25,31,33)	0	.0
BLACK SPRUCE (41,42,43)	240	10.0
MOUNTAIN HEMLOCK (45,46)	0	.0
COTTONWOOD (27,28,29,35,36)	0	.0
MIXED FOREST (22,24,26,32,34)	1550	64.6
SALT WATER WETLANDS (50,51,52)	0	.0
TALL SHRUBS (60,61)	90	3.8
LOW SHRUB (62)	0	.0
GRASSLAND (63)	0	.0
TUNDRA (64,65,66,67)	0	.0
FRESHWATER WETLANDS (68,69)	500	20.8
CULTURAL FEATURES (70)	0	.0
BARREN (MUD,ROCKS) (81,82)	0	.0
PERMANENT SNOW & ICE (82,83)	0	.0

GAME	UNIT	M7	M8	M9	M10	M11	M12	M13	M14	B1	B2	B3	B4	CGS1	CGS2	CGS3	CGS4	CGS5	CGS6	NEST	WFBSG1	WFBSG2	WFBSG3	R1
	1149	2	2	2	2	1	1	1	1	1	2	2	1	0	0	0	0	0	0	1	1	2	1	3

FISH	UNIT	SPECIES	F1	F2	F3	F4	F5	F6	F7
	1149	RAINBOW TROUT	1	2	2	1	1	1	1
		COHO SALMON	1	2	2	1	1	1	1

Table B-2

Maps compiled in ADF&G Susitna Area Plan – Fish and Wildlife Atlas

A. Introduction

- A1a Susitna Area Plan Subregional Boundaries
- A1b Susitna Basin Subbasins Data-base Boundaries
- A2a Resource Analysis Units (1:500,000)
- A2b Resource Analysis Unit Inset (1:250,000)
- A3a Harvest Report Code Units – Moose
- A3b Harvest Report Code Units – Caribou
- A3c Harvest Report Code Units – Sheep

B. Supply

- B1 Moose Seasonal Distribution
- B2 Caribou Seasonal Distribution
- B3 Dall Sheep Seasonal Distribution
- B4 Brown Bear Seasonal Distribution
- B5 Black Bear Seasonal Distribution
- B6 Waterfowl, Seabird, Raptor Seasonal Distribution
- B7 Anadromous Fish
- B8 Resident Fish
- B9a Moose Habitat Suitability – Summer
- B9b Moose Habitat Suitability – Winter
- B10 Moose Enhancement Suitability Potential
- B11 Wildlife Diversity
- B12 Riparian Lands
- B13 Moose Winter Range Availability—based on estimated snow accumulation
- B14a Moose Carrying Capacity (Existing)
- B14b Moose Carrying Capacity (Potential)
- B15 Vegetation Community Types

C. Demand

C1 Modes of User Access

C2a Hunting Effort for Moose

C2b Hunting Effort for Caribou

C2c Hunting Effort for Sheep

C3 Sport Fishing Location, Access, and Effort

C4 Local Community Resource Use Areas

C5 Fish and Wildlife Habitat Lands (Fish and Wildlife Element Map)

C6 Fish and Wildlife Areas meriting Legislative Consideration for Special Management

Appendix C:

Habitat Evaluation Procedures (HEP) Models

applied in the Susitna River Basin

1. Description of HEP models applied in the Willow Subbasin:

   a) moose

   b) willow ptarmigan

   c) spruce grouse

   d) snowshoe hare

   e) red squirrel

2. Description of revised moose model applied in Talkeetna and Beluga Subbasins

United States Department of the Interior

FISH AND WILDLIFE SERVICE
1011 E. TUDOR RD.
ANCHORAGE, ALASKA 99503
(907) 276-3800

IN REPLY REFER TO:
WAES

29 MAY 1981

Weymeth Long
State Conservationist
U.S. Soil Conservation Service
2221 E. Northern Lights
Anchorage, Alaska 99504

Dear Mr. Long:

Enclosed please find the Technical Appendix - Fish and Wildlife Resources for the Willow Subbasin portion of the Susitna River Basin Cooperative Study. This Technical Appendix is the explanatory background for the wildlife habitat models prepared by our field office to satisfy our cooperative agreement with the U.S. Soil Conservation Service and Alaska Department of Fish and Game.

So that the Technical Appendix may serve as a complete document, we have attached copies of your brief vegetation type descriptions and mapped outputs for the Subbasin habitat models. However, the Technical Appendix will be most useful if it is made available in conjunction with your full report.

We appreciate the opportunity to participate in the Susitna River Basin Cooperative Study and look forward to our further coordination with you and with the state in completing the study.

Sincerely,

Assistant Original Signed by Keith Bayha

Regional Director

Attachment

cc: Carl Yanagawa, ADF&G
Randy Cowart, ADNR

Susitna River Basin
Cooperative Study--
Willow Subbasin

Technical Appendix - Fish and Wildlife Resources

A. INTRODUCTION

Programs to actively protect and enhance Alaska's fish and wildlife resources can minimize decreases in fish and wildlife habitats and populations which will inevitably accompany settlement and development of the state. One of the goals of government fish and wildlife agencies is to encourage environmentally sound land use practices. These agencies work to minimize fish and wildlife resource losses by directing necessary developments to areas of less value for fish and wildlife and by recommending land use practices which will maximize fish and wildlife values on developed lands.

The Susitna River Basin Cooperative Study (SRBCS) provided an opportunity for the U.S. Fish and Wildlife Service (FWS) and the Alaska Department of Fish and Game (ADF&G) to develop and recommend land use practices which could protect and enchance fish and wildlife resources in the rapidly developing Susitna River Basin. One step in this coordinated effort consisted of identifying potentially suitable wildlife habitats. Identified habitats, additional fish and wildlife information and data on other resources was then coordinated in planning land use alternatives for the Susitna Basin.

While participating in the SRBCS, the FWS and ADF&G have focused on two activities: (1) assessing the fish and wildlife resources of the Willow Subbasin (Section 4.27 of main report); and (2) correlating the distributions of selected wildlife species to specific habitat characteristics.[1]/ This Technical Appendix explains how habitat suitability models were used to make these correlations.

B. METHODOLOGY

Fish and wildlife resources can be assessed in terms of (1) population distributions and abundances, and (2) habitat suitability. Known fish and wildlife use areas have been delineated (ADF&G 1973, 1978a and b). To analyze habitats in terms of their suitability in meeting a species' life requisites, a theoretical approach involving computer models was taken.

1. Key fish and wildlife use areas

Distributions of subbasin fish and wildlife species have previously been mapped at a scale of 1:250,000 (ADF&G, 1973, 1978a and b). For the SRBCS, ADF&G area biologists refined this information for display on mylar overlays of 1:63,360 topographic base maps covering the study area.

1/ The Susitna River Basin has been divided into four subbasins for the purposes of this study. The Willow Subbasin report is to be completed early in 1981 while analysis of the Talkeetna Subbasin is scheduled for later in 1981. The Beluga and Upper Susitna Subbasins will be covered in 1982.

Distributions of many of the game bird and mammal species,[2/] as well as anadromous fish streams, mapped by ADF&G have been rectified and digitized by Environmental Systems Research Institute (ESRI) Redlands, California, as part of the data base for the study. Much of the existing data on terrestrial species is general and differs in detail throughout the study area (ADF&G, 1980). However, the ADF&G data on species distributions and use areas provided a check for modeled habitat suitabilities.

2. Models of habitat suitability

Habitat suitability for six wildlife species was modeled by examining the relationship between those species' habitat requirements and the physical and biological characteristics of the Willow Subbasin.

Species were chosen for modeling if they were: (1) addressed in the Terrestrial Habitat Evaluation Criteria Handbook-Alaska (USFWS, 1980a); (2) covered by ADF&G distribution and abundance data; (3) widespread or present in several habitats within the subbasin; and (4) dependent upon habitat parameters which could be assessed using vegetation, soils, and other data mapped during the Cooperative Study. Habitat models were developed for spruce grouse (Canachites canadensis), willow ptarmigan (Lagopus lagopus), snowshoe hare (Lepus americanus), red squirrel (Tamiasciurus hudsonicus), beaver (Castor canadensis), and moose (Alces alces).

(a) The Terrestrial Habitat Evaluation Criteria Handbook - Alaska

The FWS Terrestrial Handbook for Alaska provided the general methodology for modeling wildlife habitat suitabilities in a manner comparable with other resource use suitabilities (e.g. agriculture, timber, settlement, recreation).

The Handbook offers the most complete data base available on species-specific habitat requirements. It was developed for use with the national Habitat Evaluation Procedures (HEP) program (USFWS, 1980b). HEP provides a methodology for systematically measuring vegetation, soils, and other environmental data and then using these data to evaluate the habitat suitability of an area for a particular species. The HEP methodology may also be used to predict how habitat suitability will change over time, with and without various developments. The Terrestrial Handbook is organized into individual "species accounts" for 29 wildlife species found in Alaska. Species accounts are based upon information from published and unpublished sources, as well as on the judgements of species experts. Species accounts include narrative summaries of habitat requirements for food, cover, reproduction, and other life requisites. General habitat types (e.g. tundra, low shrublands, coniferous forests) which provide suitable environmental conditions for each species life

2/The 26 wildlife species mapped by ADF&G are: sharp-tailed grouse, spruce grouse, rock ptarmigan, willow ptarmigan, white-tailed ptarmigan, snowshoe hare, hoary marmot, arctic ground squirrel, red squirrel, flying squirrel, beaver, muskrat, porcupine, coyote, gray wolf, red fox, black bear, brown bear, marten, weasel, mink, wolverine, river otter, lynx, moose, and Dall's sheep. Fish species covered by the anadromous fish streams map include: chinook, sockeye, coho, chum, and pink salmon.

requisite are identified; and graphs and equations for computing species-specific habitat suitability index (HSI) values for a particular area are provided. Mathematical models were developed using data referenced in the species accounts.

The HEP system provides an experimental method for quantifying the relationship between certain physical or biological habitat characteristics in an area and the potential suitability of that area for a particular species such as moose or ptarmigan. Habitat characteristics or "habitat parameters" are measured in the field and then assigned suitability index (SI) values of from 0.0 to 1.0 according to graphs provided in the HEP species accounts. An SI value of 1.0 indicates that the parameter, as measured (e.g. percent tree canopy cover), is optimum in the area under study, while a value of 0.0 is assigned when a habitat characteristic is limiting to a particular wildlife species. Handbook graphs and life requisite equations can be used as diagnostic tools for determining the factors potentially limiting a species in specific habitats.

Using HEP, only those vegetation cover or habitat types in which a species of interest is found are evaluated; only those life requisites which that habitat supplies are considered. When a species utilizes a variety of habitat types, different factors become important depending on which type is considered.

(b) Habitat Types as Classified by Vegetation

Habitat types can be distinguished and categorized on the basis of vegetation composition. As a result, A Suggested Classification for Alaskan Vegetation (Fourth Revision) (Dyrness and Viereck, 1979) provided the vegetation classification system used for both the Terrestrial Handbook and SCS field sampling and mapping of the subbasin. This system is a hierarchical framework and descriptive nomenclature for the classification of Alaskan vegetation. For the classification levels used here, the Fourth Revision cited above is essentially the same as the updated version published in 1980.

In order to promote compatibility of resource inventory data collected by different organizations, and studies, the Dyrness and Viereck vegetation classification system was devised to be usable by any researcher, planner, or land manager in Alaska.[3/] The dynamic nature of the system allows revisions as necessary to accomodate new information and additional vegetation categories.

The classification scheme consists of five levels, starting with general vegetation formation (forest, shrubland, tundra, herbaceous, and aquatic)

3/Creation of the system was under the guidance of the Interagency Committee on the Classification of Alaskan Vegetation, formerly sponsored by The Joint Federal - State Land Use Planning Commission. Upon termination of the Commission in June 1979, committee activities were transferred to the Alaska Land Managers Cooperative Task Force.

at Level I and continuing to specific plant communities at Level V. Level II was used both for HEP species accounts and for baseline mapping of vegetation in the Willow Subbasin:

Forest - coniferous
- mixed coniferous-deciduous
- deciduous

Tundra[4] - sedge-grass
- herbaceous
- shrub
- mat and cushion

Shrubland - tall
- low

Grassland[5] - tall
- herbaceous-sedge

Subbasin vegetation was mapped using 1:63,360 scale color infrared aerial photographs and field data collected in summer 1978. For this mapping the SCS subdivided the Level II vegetation categories into Level III and, in some cases, Level IV categories. A total of 30 vegetation types, in addition to categories of disturbed/barren and water, were distinguished. Species habitat parameters were then evaluated in each vegetation type used by the species being considered. General HEP habitat types (Level II) are correlated to more detailed SCS vegetation types (Levels III and IV) in Table 1.

Table 1 was used to determine which vegetation types should be considered potentially suitable habitats for each of the six wildlife species considered. Suitability Index (SI) values were determined for the habitat parameters which occured in a given vegetation type and affected at least one of the six evaluation species. SIs for the habitat parameters in a given vegetation type were then combined to produce an overall habitat suitability value indicating how well that vegetation type met a particular species life requisites. Habitat parameters were evaluated using data ranging from quantified measurements of tree heights, shrub and tree canopy cover, or moss ground cover, to estimations of dominant plant species, and to more qualitative assessments such as the accessibility of escape terrain for Dall's sheep.

Specific data for evaluating parameters such as tree heights or percent shrub canopy cover do not exist for the entire study area. However, by combining the three sources of information avaliable, suitability values could be determined for several vegetation habitat parameters without specific local data. These three sources were: (1) SCS descriptions of vegetation cover types (attached); (2) field data from sampled sites; and (3) consultations with U.S. Forest Service and SCS biologists, range scientists, and foresters involved with study design and field sampling.

4/The tussock tundra type is not present in the Willow Subbasin.

5/Grasslands are actually termed "herbaceous" in the Alaska vegetative system. For the purposes of this study and consistency with SCS typing and sampling, the tall and mid-grass categories have been grouped together as tall grass.

Table 1. SCS vegetation classification system used in the Willow Subbasin as correlated to the U.S. Fish and Wildlife Service Habitat Evaluation Procedures classification (Dyrness and Viereck, 1979).

HEP	SCS Vegetation Categories
	Closed Forests (50% crown cover)
coniferous	21 = Coniferous, White Spruce, Short Stands
deciduous	22 = Deciduous, Mixed, Young Stands
mixed	24 = Deciduous, Mixed, Medium-aged Stands
coniferous	25 = Coniferous, White Spruce, Tall Stands
mixed	26 = Deciduous-Mixed, Old Stands
deciduous	27 = Cottonwood, Young Stands
deciduous	28 = Cottonwood, Medium-aged Stands
mixed	29 = Cottonwood, Old Stands
	Open Forest-Woodland (10-50% crown cover)
coniferous	31 = Coniferous, White Spruce, Short Stands
mixed	32 = Deciduous, Mixed, Medium-aged Stands
coniferous	33 = Coniferous, White Spruce, Tall Stands
mixed	34 = Deciduous-Mixed, Old Stands
deciduous	35 = Cottonwood, Medium-aged Stands
mixed	36 = Cottonwood, Old Stands
	Black Spruce and Mountain Hemlock
coniferous	41 = Black Spruce, Closed, Short Stands
coniferous	42 = Black Spruce, Closed, Tall Stands

coniferous	43 =	Black Spruce, Open, Short Stands
		Non-Forest (10% crown cover)
tall grass	50 =	Saltwater Wetlands, Grassland
low shrub	51 =	Saltwater Wetlands, Low Shrub
herbaceous sedge-grass	52 =	Saltwater Wetlands, Tidal Marsh
tall shrub	60 =	Tall Shrub, Alder
tall shrub	61 =	Tall Shrub, Alder-Willow (streamside)
low shrub	62 =	Low Shrub, Willow-Resin Birch
tall grass	63 =	Grassland
sedge-grass tundra	64 =	Tundra, Sedge-Grass
herbaceous tundra	65 =	Tundra, Herbaceous
shrub tundra	66 =	Tundra, Shrub
mat & cushion tundra	67 =	Tundra, Mat and Cushion
herbaceous sedge-grass	68 =	Fresh Water Wetlands, Sphagnum Bog
low shrub	69 =	Fresh Water Wetlands, Sphagnum-Shrub Bog
		Non-Vegetated
disturbed	70 =	Cultural Features
-	82 =	Snowfield
-	83 =	Glacier
		Water
freshwater	91 =	Lakes 40 ac.
freshwater	92 =	Lakes 10 ac. 40 ac.
freshwater	96 =	Streams and Rivers 165 ft. 660 ft. wide
freshwater	97 =	River 1/8 mile wide (660 ft.)

A map of the vegetation types listed in Table 1 was part of the data base automated by ESRI for use in modeling the different resource capabilities of the study area. Computerized data on soil types, the presence of water and proximities of various vegetation types or habitat features were also available in assessing habitat parameter values.

(c) Species and habitat suitabilities modeled for the study

Habitat suitability was mapped according to two multi-species habitat models.[6/]

Model A: moose, snowshoe hare
Model B: willow ptarmigan, spruce grouse, red squirrel

Computer model outputs consist of maps which display habitat types in terms of their suitability to support the life requisites of the wildlife evaluation species. Thus output maps show areas providing unsuitable, low, or suitable habitat for the life requisites of particular species. Habitat types potentially suitable for each species' life requisites are presented in Table 2. Species may be found to a limited extent in vegetation types other than those specified in the table or delineated on final study maps.

The degree of resolution possible in the habitat suitability models was limited by two factors: (1) the general, rather than site-specific, nature of information available for most of the Willow Subbasin; and (2) time and budget constraints. Thus it was not possible to divide habitat suitability categories beyond "unsuitable", "low", and "suitable" as described below:

unsuitable -areas with a 0.0 suitability index value for at least one habitat parameter;

low suitability -areas with suitability indices less than 0.4 but greater than 0.0 for approximately half of the parameters used to assess habitat suitability; these areas are potentially limiting to a given wildlife species.

suitable -areas which are generally not limiting for a given species' life requisite(s); the suitability index of each applicable habitat parameter was approximated to be at least 0.4.

Relative weighting of each habitat parameter is incorporated into parameter graphs (e.g. Figures 1 through 4) by the range of possible SI values (USFWS 1980a). Thus while graphed SI values of less important parameters may range between 0.8 and 1.0, graphed SI values for more important parameters may drop to zero. Parameters with a narrow range have much

6/A third habitat model was developed for beaver. Due to time and funding constraints, this model could not be analyzed by computer. The beaver model may be revised and utilized in analyzing wildlife habitats in other parts of the Susitna River Basin.

Table 2. Life requisites modeled for each species by habitat type[1/]

Species	HABITAT TYPE		
	Coniferous Forest	Mixed Coniferous-Deciduous Forest	Deciduous Forest
Moose	WR, WC C S/S/F F S/S/F	WR, WC C S/S/F F S/S/F	WR, WC C S/S/F F S/S/F
Snowshoe Hare	F Repro. C	F Repro. C	F Repro. C
Willow Ptarmigan	F Repro. C WR		
Red Squirrel	F Repro. C	F Repro. C	F C
Spruce	F (S/SF/ Repro. C WR	F S/S/F Repro. C WR	
Beaver[2/]		F C	

1/ Based upon species accounts in USFWS 1980 Terrestrial Habitat Evaluation Criteria Handbook-Alaska. Moose life requisites were modified for the Willow Subbasin, see Section C, Part 1.

2/ Areas suitable as beaver habitat must be within 880 yards (805 m) of water and include all perennial water bodies, streams, and rivers. Because of funding limitations, the beaver model was developed but not analyzed by computer.

Symbols: WR = Winter Range WC = Winter Cover F = Food
S/S/F = Spring/Summer/Fall C = Cover Repro. = Reproduction

Table 2. Life requisites modeled for each species by habitat type[1/]

Species	HABITAT TYPE					
	Shrublands		Grasslands		Tundra	
	Tall	Low	Tall	Herbaceous-Sedge	Shrub	Mat and Cushion, Tussock, or Herbaceous
Moose	WR WC C S/S/F F S/S/F	WR F S/S/F	C S/S/F F S/S/F	F S/S/F	F S/S/F	F S/S/F
Snowshoe Hare	F Repro. C					
Willow Ptarmigan	F Repro. C WR				F Repro. C WR	
Beaver[2/]	F C	F C				

1/ Based upon species accounts in USFWS 1980 Terrestrial Habitat Evaluation Criteria Handbook-Alaska. Moose life requisites were modified for the Willow Subbasin, see Section C, Part 1.

2/ Areas suitable as beaver habitat must be within 880 yards (805 m) of water and include all perennial water bodies, streams, and rivers. Because of funding limitations the beaver model was developed but not analyed by computer.

Symbols: WR = Winter Range WC = Winter Cover F = Food
S/S/F = Spring/Summer/Fall C = Cover Repro. = Reproduction

less influence on an overall numerical suitability value than do parameters with wide ranges. Those parameters which can be assigned an SI value of 0.0 may be considered limiting factors. Consequently the life requisites evaluated by such limiting parameters would be limited with an overall SI = 0.0 Descriptions of the life requisite(s) for which identified areas are limiting or unsuitable are included in the accompanying species-specific accounts.

(d) Example of rationale behind habitat models

SI values for several habitat parameters were rated for more generalized habitat categories formed by groupings of SCS vegetation types (e.g. open forests). An example of these groupings and the modeling of habitat suitability is detailed below for snowshoe hare. Only generalized descriptions of modeling procedures are given in the attached accounts for all other evaluation species. "Percent tree canopy cover" was one of four parameters used to compute SI values for snowshoe hare cover and reproduction in forest types. According to the Terrestrial Handbook account for snowshoe hare, closed forests are of greater value for cover and reproduction than are open forests because they offer greater protection from predators (USFWS 1980a).

SCS defined forest types 21, 22, 24, 25, 26, 27, 28, 29, 41, and 42 as having a canopy closure greater than 50 percent. All other forest types were classified as open forests with canopy closures of from 10 to 50 percent. Therefore the closed forest types listed above could be assigned a high SI value (0.8 to 1.0) for the snowshoe hare tree cover parameter; those types fall within the high range on the appropriate HEP graph. Open forest types can similarly be assigned a moderate SI value (0.4 to 0.8).

Where data on some parameters were lacking, information on the remaining parameters could be composited to determine the overall habitat value as long as none of the remaining factors was limiting (i.e. $SI > 0$). For example, to measure food value for a given species, five parameters might be identified in the Handbook. Yet, it might be possible to approximate only four of these parameters from data available in the study area. Assume at least three of the measurable parameters have suitability indices of at least 0.4 and none can be assigned an SI = 0.0. Then habitat suitability from the geometric mean of all five parameters should be at least moderate, even if the unknown parameter has a low suitability index ($0.0 < SI < 0.4$). Thus it would be unnecessary to determine the fifth parameter. However, if one or more parameters were assigned an SI = 0.0, the life requisite was considered limited. The appropriate area was then mapped as unsuitable for that life requisite and species.

(e) Limitations to usefulness of the study models

Two factors may limit the validity of the Terrestrial Handbook species models and the habitat models developed for this study. To begin with, a certain amount of interpretation and judgment was involved in compiling existing data for the Handbook. Handbook authors, however, did give highest priorities to Alaskan research and to information derived through empirical methods (USFWS 1980a). Limitations of available information and reservations concerning use of information on species habitat requirements are described in each species account; these limitations were taken into account in developing habitat models for the Willow Subbasin. Secondly, Handbook models have only recently been developed. Thus the models have not previously been tested or used in areawide planning.

Every effort was made to overcome these limitations, including: (1) discussions with ADF&G and USFWS biologists regarding model assumptions and applicability to the study area; (2) review by ADF&G area biologists of initial habitat suitabilities mapped by computer; and (3) field verification of habitat characteristics and suitabilities identified on the computer outputs.

It must also be noted that the resolution of modeled information is relatively general. Because the minimum mapping unit was 10 acres (4 ha), valuable riparian or other areas smaller than 5 acres may not be identified (see Section 4.28, Wetlands, for further discussion of minimum mapping unit effects). In applying model outputs to specific areas, an on-ground site evaluation must be made to identify valuable streamside corridors or other small areas.

A final caution must be added before the specific habitat models are described. Habitat conditions are not static. They change with both natural and human-induced plant succession, as well as with other natural and cultural processes such as flooding, clearing, earth movements, fire, etc. As a result, conditions modeled in the report are not necessarily the conditions which will exist in the future. Plant succession is addressed in the main report (Section 4.27). Succession and other dynamic processes should be considered when applying the habitat models and when developing long-range management plans.

C. INDIVIDUAL SPECIES HABITAT MODELS

Since separate models of Wetlands and Land Use Constraints (including anadromous fish streams) were developed during the study, the habitat models were focused on terrestrial upland species. It was assumed that areas most important to fish and waterfowl would be delineated by Wetlands and Land Use Constraints models.

The following discussion is divided into a species-by-species description of habitat requirements related to Willow Subbasin features. Unless otherwise referenced, all information on species habitat requirements and life requisites is adapted from the Terrestrial Handbook (USFWS 1980a). Additional information and reference lists are available in the Handbook.

1. Moose -- Alces alces

(a) Subbasin moose populations

Highly visible and widely distributed throughout Alaska, moose are the object of a multi-million dollar hunting and guiding business, provide important meat supplies for many people, and are a popular subject for observation and photography. The over 800,000 acres of suitable moose habitat within the one million acre Willow Subbasin support 2,000-4,000 moose. This highly valuable wildlife resource is located within a 2-hour drive of half the state's human population. Nearly half of the state's licensed hunters and trappers reside in this area: 23,644 in Anchorage and 3,525 in the Matanuska-Susitna Borough in 1979.

In additon to being highly accessible to large numbers of people, Subbasin moose populations are highly productive, as indicated by population estimates, calf:cow ratios, and twinning rates. A unique combination of environmental and cultural conditions is responsible for the high moose productivity in the area:

1) availability of suitable habitats for year-round food and cover--Nutrition has been widely accepted as a major determinant of moose productivity. Calf:cow ratios, twinning rates, and winter mortality are all related to nutrition, and therefore to quality and quantity of forage. Preferred forage species such as young-growth willow, birch, and aspen, aquatic forbs, and other herbaceous species are currently abundant and widespread throughout the Subbasin. In addition, different vegetation types providing alternative food sources are highly interspersed with one another and with protective cover vegetation. Wetlands, which provide nutritious succulent forbs and may be favored calving areas, cover approximately two-thirds of the Subbasin.

2) moderate maritime climate--Cool moist summers and mild winters prvide a climate favorable for moose. In particular, winter moose mortality in the Subbasin is relatively low most years because the depths, density, hardness, and duration of snows in the area generally do not seriously reduce moose mobility or food availability. Snow accumulations at the lower elevations are normally not heavy, and frequent strong winds in the Subbasin reduce snow cover on exposed sites. In addition, strong winds privde relief from insects during summer and fall. Climatological conditions in the Willow Subbasin are noticeably favorable in comparison to conditions immediately to the north, where average temperatures are colder and snow depths greater (Didrickson 1968). The more favorable climate of the Willlow Subbasin is believed to allow greater numbers of calves and older age-class individuals to survive the winter (Didrickson, 1968 and pers. comm. 1980).

3. low natural predation--Long-term and widely dispersed human settlement in the Subbasin has significantly reduced wild predator populations. In particular, wolves, black bear, and brown bear numbers are kept low by trapping, hunting, and defense-of-life-and-property kills. These three predator species can significantly contribute to moose mortality and their absence increases moose survival rates.

4) historical disturbances, both natural and human-caused--Natural disturbances such as wildfires, flooding, and glacial movements; and human-caused disturbances such as logging, accidental and intentional fires, clearing for roads, homesteads, agriculture, etc. promote the early successional browse species which characterize productive moose habitats. Prior to the early 1940's, early successional browse was not abundant in the Subbasin and moose were consequently scarce. As outlined by Chatelain (1951) and Didrickson (1968), great numbers of moose first appeared about 1947-48, responding to habitat changes casued by human exploration and settlement. Specifically, during the 1920's and 30's, activities of miners, railroad construction crews, and early settlers changed subbasin vegetation by clearing and burning timber. Large areas of the Subbasin were burned about 1924 and reburned about 1940, with smaller fires in between. As a result, early seral vegetation suitable for moose browse appeared where such vegetation had not existed before. Triggered by the sudden abundance of food, and abetted by the favorable climate, the high reproductive capability of moose caused a rapid increase in Subbasin moose populations.

Moreover, until the late 1960's, Subbasin moose habitat originally created in the 1920's-40's was largely maintained by the constantly changing patterns of human land use, especially homesteading, in the area. New homesteads were cleared while others, previously cleared, were abandoned and reverted to moose browse. The result was the continual production of new moose browse as old browse underwent successional changes and declined in productivity.

Since the late 1960's, reductions in land-use activities beneficial to moose have caused some declines in the quality and quantity of Subbasin moose habitats. Nonetheless, the moderate climate, availability of suitable plant communities, and low predation characteristic of the Subbasin still permit large moose populations which can benefit greater numbers of people more easily than any other big game populations in the State. If moose habitat can be maintained and/or enhanced, this wildlife resource can remain available for the long-term use and enjoyment of thousands of people.

Moose utilize a variety of habitats, depending on climate, availability, tradition, and seasonal needs. As seen in the Willow Subbasin, moose generally coexist with humans when protected from over-exploitation. However, Subbasin moose populations will decline as the quantity and quality of moose range is diminished through settlement, development, and fire supression (ADF&G 1973). Loss of range has been and will probably continue to be the primary negative human impact to moose in the Willow Subbasin (Jack Didrickson, ADF&G, pers. comm., May 1980). Moreover, with increasing vehicular traffic and the paving of additional roads, road mortality can be expected to rise and mortality from trains to remain a significant impact.

(b) Moose habitat use

As noted previously, moose are associated with seral communities created by fire, glacial, or fluvial action, as well as with climax upland shrub and lowland bog communities. Upland willows along streams and birch in drier sites are important in summer and autumn; in areas of light snow accumulation, upland shrubs may be used all year. Important moose summer range is found in lowland bogs. These bogs are characterized by an intricate mosaic of black spruce forests, wet herbaceous vegetation, shrubs, subclimax hardwood communities, and numerous intermediate successional stages. Key winter range is provided by the successional communities of birch-willow-aspen shrub thickets with a high proportion of willows.

Quality and distribution of food plants are of prime importance in meeting moose nutritional requirements and providing a preferred variety of forage. Browse[7/] is the winter staple, with willow (Salix spp.) the

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7/ Browse is here defined as woody stems eaten after deciduous leaves have dropped.

preferred species. Birch (Betula spp.), cottonwood (Populus spp.), and aspen (Populus tremuloides) are utilized heavily in areas where willow is scarce or absent. Some low-growing species such as lowbush cranberry (Vaccinium vitis-idaea) and foliose lichens (Peltigera spp.) are important alternative winter foods. As a variety of terrestrial and aquatic herbaceous plants becomes available, use of browse ceases through late spring and summer. In fall, browse again becomes of prime importance.

In summer, moose are frequently seen feeding in open areas and utilizing bordering shrub and forest areas for cover. Winter cover needs are generally determined by the influence of climatic factors, particularly snow and wind, on food availability and animal mobility. Mature forest stands with dense canopies provide cover for escape from wind and snow, especially in late winter. Moose generally prefer more open, shrub-dominated areas and sedge meadows in early winter when snow depth is minimal. In late winter, moose shift to closed canopy coniferous and deciduous riparian habitats where snow accumulation is reduced, and ground vegetation more visible than in the shrub and open meadow habitats.

Wet, marshy lowlands, characterized by open areas interspersed with dense stands of shrubs and trees, are commonly observed to serve as moose calving grounds. Openings with abundant early spring forage are frequently used as calving areas. However, identification of calving concentrations in open wetlands may be attributed as much to greater ease of human observation as to actual moose distributions (Didrickson, pers. comm.). Islands in rivers and lakes are also often used for parturition. Studies of radio-collared moose provide evidence that moose utilize nearly all suitable feeding and cover habitat types for calving; quantitative information on varying levels of use among different types is lacking.

Frequently, the value of a habitat for moose depends on its proximity to other habitat types. A mixture of vegetation types can provide cover habitat in close proximity to feeding habitat and a variety of alternative food species and successional stages. Optimally interspersed habitat will supply all requirements within a minimum area, although home range size for moose is variable. While some moose populations make substantial and traditional seasonal movements, other populations are predominantly sedentary.

(c) Moose habitat model

For the purposes of this study, the moose habitat model in the Terrestrial Handbook (USFWS 1980a) was modified to take into consideration habitat characteristics and moose activities within the Willow Subbasin, as well as the generalized nature of the habitat information that was available. Modifications were based upon discussions with Jack Didrickson, Paul Arneson, and Warren Ballard, ADF&G, and Wayne Regelin, USFWS.

Willow Subbasin habitats were evaluated for their suitability in providing four life requisites believed essential to the area's moose: winter range, winter cover, food (spring/summer/fall), and cover (spring/summer/fall). Although reproduction with regard to parturition and the first few weeks after calves are born, is a fifth moose life requisite, calving habitats were not separately mapped. Biologists do not have sufficient information for accurately delineating or evaluating calving habitats. Water is also an important component of moose habitats but it is generally not limiting in the Willow Subbasin. The life requisites evaluated in each habitat type are listed in Table 3. The assumptions and criteria used to distinguish and model unsuitable, limited, and suitable areas within each habitat type are discussed in terms of applicable life requisites.

TABLE 3

MOOSE LIFE REQUISITES EVALUATED BY HABITAT TYPE

Potential Life Requisites	Willow Subbasin Habitat Types*										
	CF	MF	DF	TS	LS	TG	HSG	ST	HT	MCT	SGT
Winter Range	XX	XX	XX	XX	XX						
Winter Cover	XX	XX	XX	XX							
Food (Spring/Summer/Fall)	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Cover (Spring/Summer/Fall)	XX	XX	XX	XX		XX					

XX = Type was evaluated for suitability in supplying each life requisite

*CF = Coniferous forest
MF = Mixed forest
DF = Deciduous forest
TS = Tall shrub
LS = Low shrub
TG = Tall grass
HSG = Herbaceous sedge-grass
ST = Shrub tundra
HT = Herbaceous tundra
MCT = Mat and cushion tundra
SGT = Sedge-grass tundra

Winter Range--Coniferous Forest (CF), Mixed Forest (MF), Deciduous Forest (DF), Tall Shrub (TS), and Low Shrub (LS)

Winter range, as a combination of food and cover requirements, is considered the primary factor limiting moose in the Willow Subbasin (Didrickson, pers. comm.). Plant quality, plant quantity, and cover are the three factors which determine the suitability of Subbasin shrublands and forests as moose winter range. Quality of food plants is indicated by the plant species present in potentially suitable vegetation types. The vertical extent and horizontal cover of moose browse species determine food plant quantity; browse is available on plants growing to a height of approximately 10-15 feet (to 4.6 m), or on those which can be bent over (i.e. plants with circumferences less than 5 inches (3 cm)).

Suitable winter ranges must also provide cover for thermal protection, to keep snow off browse plants, and to prevent snow accumulations that restrict animal mobility. Such ranges are indicated by the percent coniferous tree canopy cover, defined by vegetation type.

The ability of Subbasin habitats to provide these three factors was determined using SCS vegetation type descriptions, SCS measurements of vegetative production (Table 4), and further details provided by SCS and USFS personnel. Numbers corresponding to SCS vegetation types were previously given (Table 1).

Areas of low value as moose winter range generally consisted of those vegetation types where at least two of the three quality, quantity, and cover factors described above are limited. These areas are as follows:

CF Type 42--closed, tall stands of black spruce: shrub and deciduous sapling cover and height values were low relative to other types.

DF Types 28--closed, medium-aged stands of cottonwood: limited availability of cover and browse.

MF Type 26--closed, old stands of mixed-deciduous forest: limited plant quality as characterized by SCS productivity measurements.

TS Type 60--alder: low plant quality as characterized by SCS; type may be used for cover if adjacent to suitable food.

Winter Cover--CF, MF, DF, TS

Winter cover is provided by the same general habitat types as is winter range, with the exception of low shrub areas. The greater the percent coniferous tree canopy, tall shrub, and sapling crown covers, the more suitable the type is as moose winter cover. Thermal protection within these types will be influenced by climatic features such as snow and wind which can limit food availability and animal mobility. Topographic relief, i.e. slightly hilly landscapes, affords greater protection than flat terrain. Minor topographic features are an important characteristic of moose winter cover which could not be measured for this study.

For the moose habitat model, winter cover was considered limited in areas with an open deciduous canopy or with a closed deciduous canopy and limited understory. Three habitat types were so limited: 27, 28, and 35.

TABLE 4

Annual Production of Willow Subbasin Vegetation Types
As Determined by U.S. Soil Conservation Service*

	VEGETATION TYPE																	
	CONIFEROUS FOREST							DECIDUOUS FOREST				MIXED FOREST						
	21	25	31	33	41	42	43	22	27	28	35	24	26	29	32	34	36
A	1000-1500	400-650	1200-2000	300-700	150-400	100-300	300-900	400-700	100-300	600-1000	400-1000	200-1000	400-1500	700-1100	1000-1800	800-1500	700-1300
B	H	M	H	M	L	L	M	M	L	M	M	M	M	M	H	M/H	M/H

	TALL SHRUB		LOW SHRUB			TUNDRA				TALL GRASS		HERBACEOUS SEDGE-GRASS	
	60	61	51	62	69	64	65	66	67	63	50	68	52
A	2500-3000	500-1500	200-800	750-1000	500-1200	200-800	300-800	500-1200	50-100	2500-3500	800-1500	300-600	400-1300
B	H	M/H	M	M	M	M	M	M	L	H	H	M	M

A Total annual production of herbaceous plants and woody shrubs (lbs/acre)

B Rating for moose forage availability - based on habitat type descriptions and personal communications provided by U.S. S.C.S. personnel

*Production was rated as follows:
high = greater than 1000 lbs/acre
moderate = 300-1000 lbs/acre
low = less than 300 lbs/acre

Spring/Summer/Fall Cover--CF, MF, DF, TS, TG

Most of the Willow Subbasin may be classified as spring/summer/fall cover (Didrickson, pers. comm.). Spring/summer/fall are defined as mid-April through early or mid-November. Habitats supplying spring/summer/fall cover are necessary to provide protection from weather in spring and hunters in late fall. None of the vegetation types potentially suitable as moose spring/summer/fall cover were considered limited.

Spring/summer/fall food--CF, DF, MF, TS, LS, TG, HSG, ST, MCT, HT, SGT

Moose can find spring/summer/fall food in nearly any habitat type where herbaceous vegetation is available. Availability and palatability of forage species affect the intensity with which moose utilize specific plant species for spring/summer/fall food. Thus the same factors of quality and quantity, important in determining winter range, must be considered here.

Spring/summer/fall food was considered limited for moose in areas of limited forage quality and low productivity as indicated by SCS measurements, Table 4. Only three types were so limited: CF type 42, MF type 26, and TS type 60.

While winter range is often termed the critical moose habitat, it is spring/summer/fall habitat which allows a moose population to achieve its greatest numbers. During those seasons moose attain the physical reserves which will sustain them through winter stresses.

(d) Limitations of model

Snow, wind, and insects are three factors which affect habitat suitability but which were not accounted for in the moose habitat model. Snowfall is highly variable on both an annual and local scale; long-term, comprehensive snowfall data do not exist within the study area. Because snow decreases food availability and restricts animal mobility, it may be the primary factor limiting an area's suitability as moose winter range. Alternatively, additional habitats may be suitable winter range in years of light snow, e.g. shrub tundra habitats where moose generally do not winter because of relatively high snow accumulations. Tundra was not considered potentially suitable as winter range.

Wind is another factor not easily measured but strongly influential in determining habitat suitability for moose. Wind may cause important forage to become available by blowing areas free of snow. At the same time, moose mobility may be reduced in wind-packed snow. Moose will be required to seek protection in extremely open, windy areas.

Summer insect concentrations in forests may cause moose to seek more exposed areas where breezes provide relief from insects, despite the concomitant loss of protection from predators. While neither snow, wind, nor insect levels can be reliably predicted for a given area, it is important to consider their influence when evaluating habitat suitability at specific sites.

One final consideration regarding the habitat suitabilities defined by this model is palatability of specific plant species. Moose do not equally select all species of willow as browse. Thus not all willow habitats are automatically better for moose than Subbasin alder habitats.

However, willow species could not be differentiated at the level of vegetation mapping undertaken during this study.

Areas identified as limited moose habitat by this modeling effort should not necessarily be eliminated as potential habitat. The greatest potential for habitat manipulation and improvement may be in those limited areas if the limitations can be eliminated or compensated.

(e) Results

Nearly the entire vegetated portion of the Willow Subbasin may be classified as suitable habitat for moose. (Note, 12 percent of the Subbasin was mapped as nonvegetated water bodies and barren or culturally-disturbed land. That area was not included in calculating areas of potential moose habitat.) Slightly more than half of the Subbasin is suitable as moose winter range or winter cover (Table 5). For spring/summer/ fall range, food is less limiting than is cover: 83 percent of the Subbasin has suitable spring/summer/fall food; only 63 percent has suitable cover. Only 1.5 percent of the Subbasin was classified as unsuitable habitat. This classification was for winter range. In total, 3.5 percent of the forest and tall shrublands were of limited suitability as moose winter range; 5 percent were of limited suitability as moose spring/summer/ fall range (the combination of food and cover life requisites during those seasons).

2. Willow ptarmigan - Lagopus lagopus

The willow ptarmigan occupies shrublands, shrubby openings in coniferous forests at or below timberline, and shrub tundra. Because it is widely distributed, abundant, and winters at lower elevations, the willow ptarmigan is the most frequently encountered game bird in the state. Hunting effort varies with bird abundance; ptarmigan populations are characterized by yearly fluctuations with 7-9 years between peaks (ADF&G, 1978a).

Although size of the harvest is unknown; ptarmigan hunting is most intensive in late winter when snow depths force birds to lower elevations. One of the most popular recreational ptarmigan hunting areas in the state is adjacent to the headwaters of the Little Susitna River in the northeast corner of the study area. Observation and photography of ptarmigan occur year-round and are popular whenever and wherever the birds are accessible.

Willow and berry plants are the prime components of the willow ptarmigan diet. While willow buds and twigs supply ptarmigan with food in winter, willow leaves and berries become important in spring and dominate in late summer. During the fall, use of willow buds and catkins increases but use of willow leaves decreases.

Ptarmigan rarely utilize dense stands of timber. Shrubby habitats with few trees are preferred in winter. Below timberline, such habitats are provided by burns, river courses, and areas disturbed by human activity. Habitat value for ptarmigan is enhanced by vegetative diversity and "edge" effect. Thus typical summer habitat consists of shrubby tundra at the upper edge of timber. Good brood cover is characterized by (1) low vegetation in moist areas where chicks can easily travel and feed, (2) high floral diversity, and (3) occasional shrubs of moderate height. Territorial sites are similarly characterized by high plant species diversity and 3 to 6-foot tall (.9-1.8 m) shrub clusters alternating with open vegetation less than 1 foot tall (.3 m). Ptarmigan avoid dense brush of any floral composition and wet marshes which tend to be shrubless.

Table 5. Acres of habitat suitable or limited for moose by habitat type and life requisite

Moose Life Requisites		Habitat Type									
		CF	MF	DF	TS	LS	TG	HSG	ST	MCT HT SGT	Total Potential Habitat
total acres of habitat in study area		171,010	243,690	35,700	49,670	66,520	14,270	125,300	1220	145,150	853,530
(%)of Total		(17.7)	(25.1)	(3.7)	(5.1)	(6.9)	(1.5)	(12.9)	(.1)	(15.0)	(88.0)
Winter Range	S	165,940	230,690	32,310	23,810	66,520					519,270 (60.8)
	L	6,070	13,010	3,390	11,640	0					34,110 (4.0)
	U	0	0	0	14,220	0					14,220 (1.7)
Winter cover	S	172,010	243,690	32,310	49,670						497,680 (58.3)
	L	0	0	3,390	0						3,390 (.4)
Spring/ summer/ fall food	S	165,940	230,690	35,700	23,810	66,520	14,270	125,300	1220	145,150	808,600 (94.7)
	L	6,070	13,010	0	25,860	0	0	0	0	0	33,300 (1.8)
Spring/ summer/ fall cover	S	172,010	243,690	35,700	38,130		14,270	109,810			613,610 (71.9)
	L	0	0	0	0		0	15,490			15,490 (3.9)

S = suitable
L = limited
U = unsuitable

1/The study area also includes 81,820 acres of barren/disturbed land and 34,910 acres of water. Thus the entire study area is 970,260 acres in size. Where no acreage is given, habitat type is not utilized for that life requisite

(a) Willow ptarmigan habitat model

Ptarmigan habitat has been defined by 14 parameters in coniferous forests and 11 parameters in tall and low shrublands and shrub tundra (Table 6, Figure 1). Food, winter range, cover, and reproduction are the life requisites evaluated within each type. Shrub tundra areas provide suitable habitat for food, cover, and reproduction. Within the Willow Subbasin, neither coniferous forests nor shrublands should be limiting for ptarmigan winter range or reproduction, when they are above 1,000 feet in elevation. However, portions of these habitats may be limiting for ptarmigan food or cover.

Areas are of limited value in providing ptarmigan food when willows constitute less than 20 percent of the total shrubs. This principle ptarmigan food is in low supply in tall alder shrublands and in both open and closed stands of white spruce.

Shrublands on dry soils, with a poor interspersion of moderately tall shrubs and low open vegetation, are of limited value for cover. The shrub understory of tall closed black spruce forests is similarly limited as ptarmigan cover. Those Subbasin shrublands on the driest soils have been classified as unsuitable for ptarmigan cover.

The lower alpine zone has been characterized as the breeding habitat of willow ptarmigan. Although not part of the computerized data base for this study, elevation can be manually delineated to identify the areas of less than 1,000 feet or greater than 4,250 feet in elevation which are unsuitable for ptarmigan reproduction.

(b) Limitations of model:

Estimations of the percent willow cover in each vegetation type utilized by ptarmigan are subject to error and may affect the validity of the ptarmigan habitat model.

(c) Results

Willow ptarmigan are primarily found in the 9.8 percent (289,420 acres) of the Willow Subbasin covered by shrubland, coniferous forest, or shrub tundra vegetation (Table 7). All of these vegetation types located between 1,000 and 4,250 feet in elevation were considered suitable for ptarmigan reproduction. The shrublands and coniferous forests were also potentially suitable as winter range. Within this area approximately 63,490 acres (1.9 percent of potential ptarmigan habitat) consist of tall alder shrublands or white spruce stands of low value for ptarmigan food. Shrublands with low food values, as well as additional shrublands and black spruce stands considered low for ptarmigan cover occur on 49,810 acres or 17.2 percent of the potential ptarmigan habitat. Another 4,100 acres (1.4 percent) of shrublands were classified as unsuitable for cover. (Note, these figures include habitats below 1,000 feet in elevation which are actually unsuitable as ptarmigan habitat. While calculation of the extent of the low elevation areas could not be made, these areas can be manually delineated on the habitat map.)

3. Spruce grouse - Canachites canadensis

Spruce grouse inhabit coniferous and mixed coniferous-deciduous forests throughout Alaska. When abundant, these grouse are extensively hunted for recreation and subsistence. The highest grouse densities in the state are found in Southcentral Alaska.

Table 6. Parameters and rules for rating habitat suitability for four life requisites of willow ptarmigan, Lagopus lagopus (adapted from USFWS, 1980a).

Food Value: Limited when $0 < I_1 < 0.4$.

Where: I_1 = Suitability Index (SI) of % willow in total shrubs

Winter Range Value: Limited if at least two of the following parameters are assigned low SI's (not evaluated in shrub tundra habitat).

Where: I_2 = SI of % tree canopy cover (coniferous forest habitats only)
I_3 = SI of % alder in total shrubs
I_1 = SI of % willow in total shrubs
I_4 = SI of % shrub crown cover

Cover Value: Limited if at least three of the following parameters are assigned low SI's.

Where: I_5 = SI of % coniferous in total trees (coniferous forest habitats only)
I_6 = SI of % tree canopy cover (coniferous forest habitats only)
I_7 = SI of % shrub crown cover
I_8 = SI of % bryophyte and graminiform cover less than 1 foot high in openings
I_9 = SI of soil drainage
I_{10} = SI of interspersion of shrubs and lower vegetation

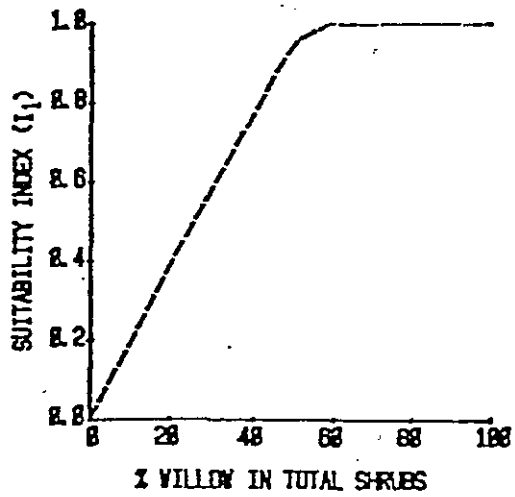
Reproductive Value: Limited if at least two of the following parameters are assigned low SI's.

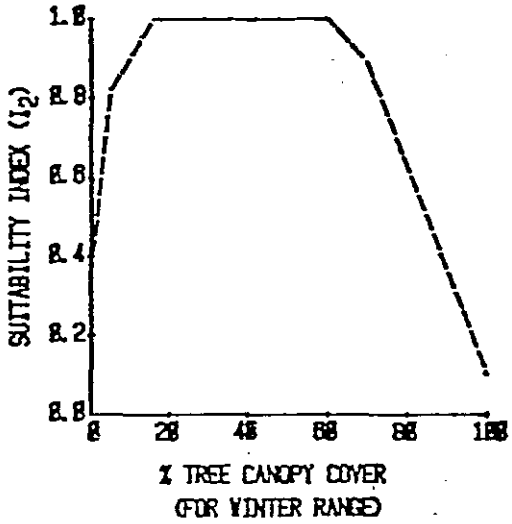
Where: I_{11} = SI of average shrub height (feet)
I_{12} = SI of % forbs in ground cover
I_{13} = SI of maximum height of ground vegetation in openings feet
I_{14} = SI of elevation (feet above sea level)

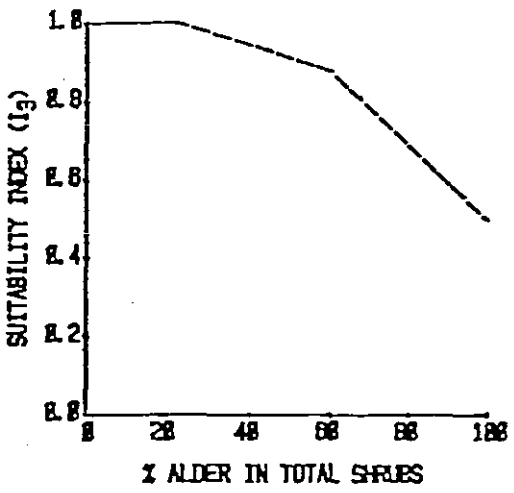
Suitability index (SI) values were derived from graphs in Figure 1 and SCS vegetation characterizations for coniferous forest, shrubland, and shrub tundra types. I = SI value for designated parameter as delineated on accompanying graphs.

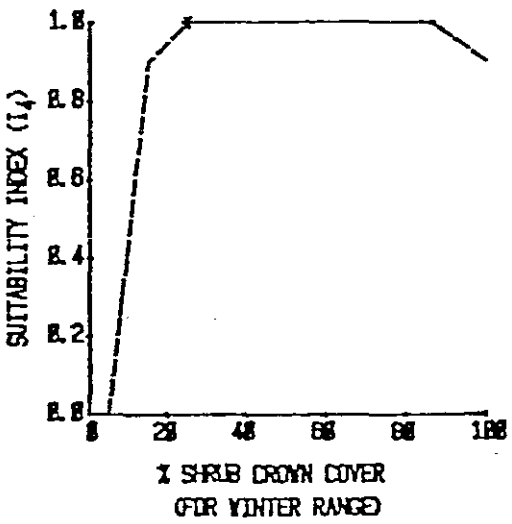
Areas where SI = 0.0 for any parameter will be unsuitable for the life requisite(s) defined in any part by that parameter. Suitability is low when $0.0 < I < 0.4$.

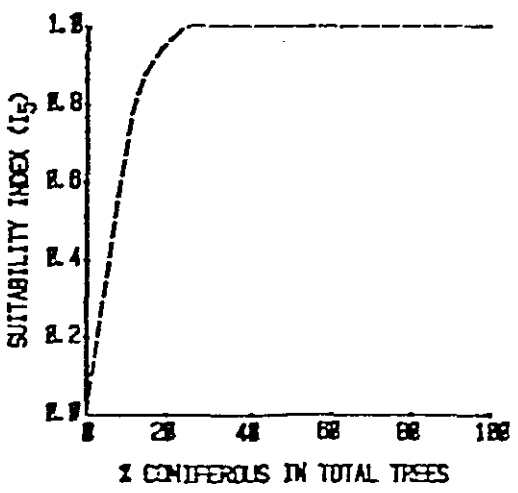
Figure 1. Graphs for determining suitability index values of parameters used to evaluate coniferous forest, tall shrub, and low shrub habitats for willow ptarmigan (adapted from USFWS 1980a).











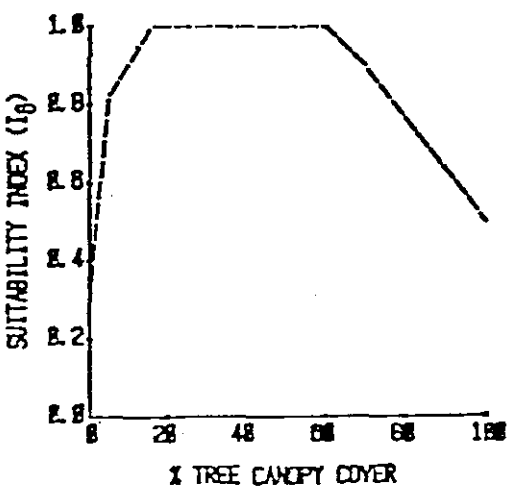
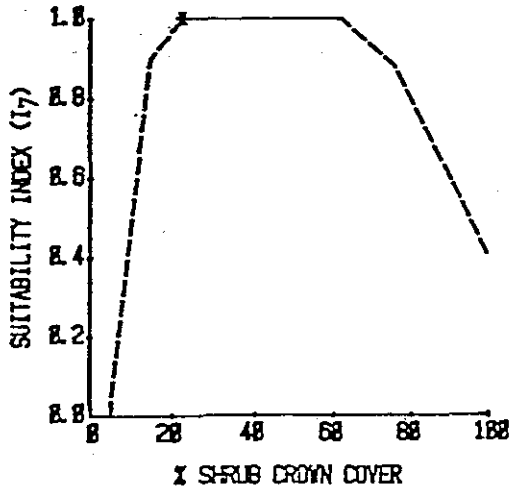
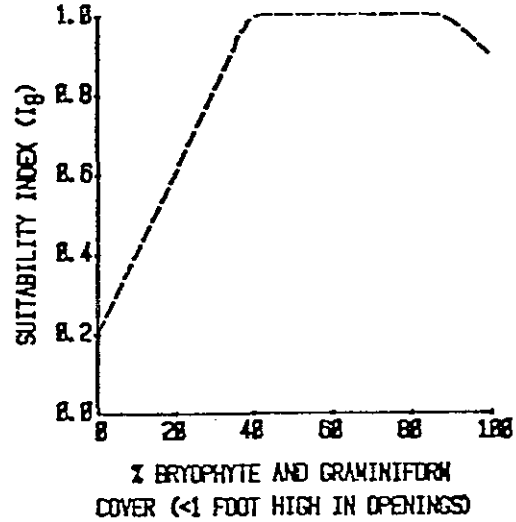
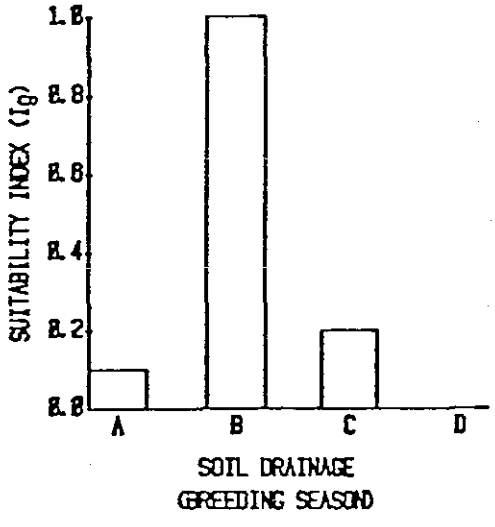


Figure 1, suitability index graphs for willow ptarmigan, continued.





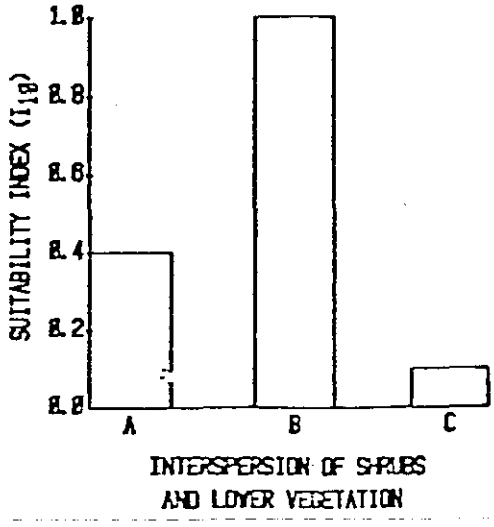


A - VERY POORLY OR POORLY DRAINED

B - SOMEWHAT POORLY DRAINED OR MODERATELY WELL DRAINED

C - WELL DRAINED OR SOMEWHAT EXCESSIVELY DRAINED

D - EXCESSIVELY DRAINED



A - SHRUBS 3-8 FT TALL, ISOLATED IN EXTENSIVE AREAS OF VEGETATION LESS THAN 1 FT

B - SHRUBS 3-8 FT TALL IN CLUSTERS SCATTERED VARIOUSLY THROUGHOUT AREAS OF VEGETATION LESS THAN 1 FT

C - SHRUBS 3-8 FT TALL IN WIDE BELTS DOMINATING AREA WITH OCCASIONAL OPENINGS OF VEGETATION LESS THAN 1 FT

Grouse prefer upland forests with from 30 percent to 90 percent of the stand composed of spruce. Understories with substantial amounts of blueberries and cranberries are also necessary for optimum grouse habitats. The spruce-berry vegetation type will provide grouse with (1) black and white spruce needles which comprise their winter diet; (2) blueberry leaves and buds, old cranberries, and unripe crowberries which are taken in increasing amounts as the snow recedes and are a substantial part of the summer diet until the gradual return to spruce needles in fall; and (3) a favorable vegetation structure for male breeding displays, for concealing chicks, and sometimes for nests.

(a) Spruce grouse habitat model

Ten habitat parameters are used to determine the habitat suitability of coniferous and mixed coniferous-deciduous forests for spruce grouse. Combinations of these parameters are used to rate habitat suitability for food (spring/summer/fall), winter range, cover, and reproduction (Table 8). As shown in Figure 2, all but three parameters in coniferous forest types and two parameters in mixed forest types were at least moderately suitable for food, winter range, cover, and reproduction ($SI \geq 0.4$).

As described by SCS, coniferous and mixed forests within the Willow Subbasin will have a percent spruce composition or tree canopy cover high enough to be given at least a moderate suitability value for grouse winter range, cover, and reproduction.

The one coniferous forest parameter which could be rated low for grouse in the Willow Subbasin is percent cover of berry-producing plants, the sole parameter used to measure spring/summer/fall food value. All four white spruce types were considered to have a berry-producing plant cover of from 5 to 15 percent. Therefore, these types were assigned a low suitability rating for grouse spring/summer/fall food (Table 9). A berry-producing plant cover of less than 5 percent, and thus an unsuitable rating, was characteristic of tall, closed black spruce stands. For the mixed forests, the cover of berry-producing plants was not considered a limiting factor for grouse spring/summer/fall food; thus in mixed forests, no parameters were assigned low suitability ratings.

(a) Limitations of spruce grouse habitat model:

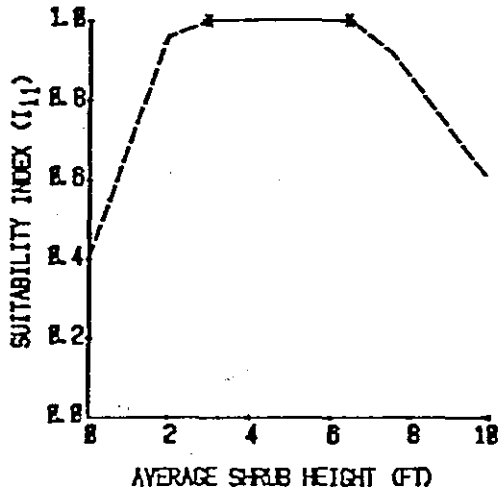
Estimations of percent cover of berry-producing plants within Subbasin coniferous forest types constitute the main potential source of error in the spruce grouse habitat model. If true percent cover substantially differs from that presented in Table 9, then the suitabilities of vegetation types rated for grouse spring/summer/fall food would change.

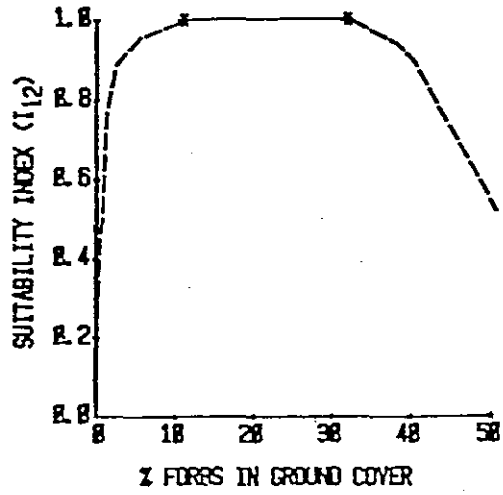
Grit is essential to grouse in the fall. Because there was no way to account for grit supplies in the grouse habitat model, some areas mapped as suitable grouse habitat may in fact be limited by insufficient grit.

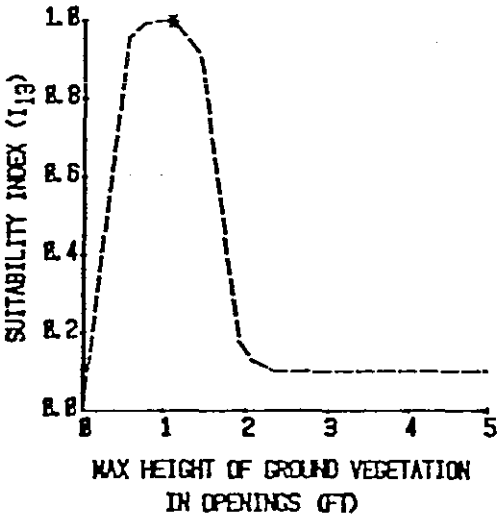
(c) Results

Approximately 42.8 percent (415,700 acres) of the Willow Subbasin is covered by coniferous and mixed coniferous-deciduous forests potentially suitable as spruce grouse winter range, cover, or reproduction habitat

Figure 1, suitability index graphs for willow ptarmigan, continued.







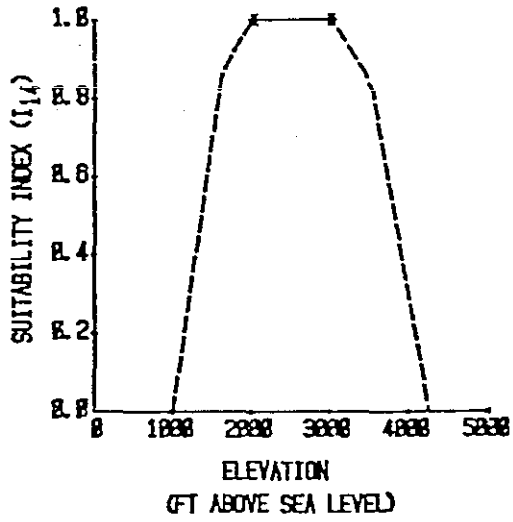


Table 7. Acres of habitat suitable or limited for willow ptarmigan by habitat type and life requisite.

Willow ptarmigan life requisites		Habitat Type: Coniferous forest	Shrublands	Shrub tundra	Total Potential Habitat
total acres of habitat in study area (% of total)[1/]		172,010 (17.7)	116,190 (12.0)	1,220 (.1)	289,420 (29.8)
Food (S/S/F)	S	139,430	85,280	1,220	225,930 (78.1)
	L	32,580	30,910	0	63,490 (21.9)
Cover	S	165,940	68,350	1,220	235,510 (81.4)
	L	6,070	43,740	0	49,810 (17.2)
	U	0	4,100	0	4,100 (1.4)
Reproduction	S	172,010	116,190	1,220	289,420 (100)
	L	0	0	0	0
Winter Range	S	172,010	116,190	--	288,200 (99.6)
	L	0	0		0

S = suitable
L = limited
U = unsuitable

--habitat is not utilized for this life requisite

1/Only those portions of these areas which are within approximately 1,000-4,250 feet in elevation are actually suitable see habitat map. The study area also includes 564,110 acres of other habitat types, 81,820 acres of barren/disturbed land, and 34,910 acres of water. Thus the entire study area is 970,260 acres.

Table 8. Parameters and rules for rating habitat suitability for four life requisites of spruce grouse, (adapted from USFWS, 1980a).

Food Value (Spring/Summer/Fall): Limited when $0 < I_1 < 0.4$.
Where: I_1 = SI of % cover of berry-producing plants

Winter Range Value: Limited if at least one of the following parameters is assigned a low SI.
Where: I_2 = SI of % spruce in stand composition
I_3 = SI of % black spruce in total spruce (coniferous forest types only)
I_4 = SI of % tree canopy cover

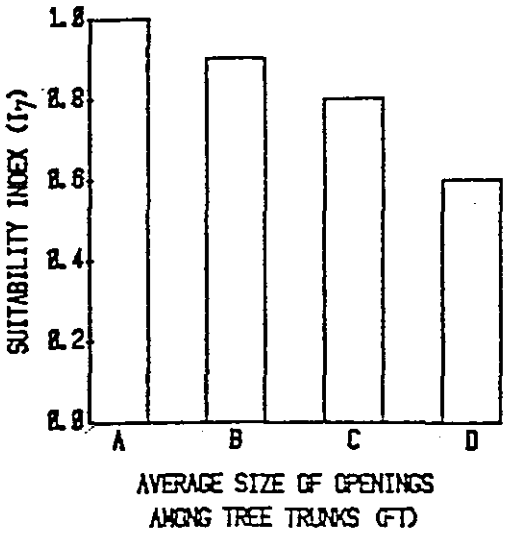
Cover Value: Limited if at least three of the following parameters are assigned low suitability indices.
Where: I_5 = SI of % combined white spruce and birch in stand composition (mixed coniferous-deciduous forest types only)
I_6 = SI of % Populus in stand composition (mixed coniferous-deciduous forest types only)
I_2 = SI of % spruce in stand composition
I_3 = SI of % black spruce in total spruce (coniferous forest types only)
I_4 = SI of % tree canopy cover
I_7 = SI of % shrub and sapling crown cover (>3 feet)
I_8 = SI of % herbaceous and woody ground cover (<3 feet)

Reproductive Value: Limited if at least one of the following parameters is assigned a low suitability index.
Where: I_9 = SI of average size of openings among tree trunks (feet)
I_{10} = SI of height of majority of trees (feet)
I_{11} = SI of average height of ground vegetation in openings at least 15 feet wide (feet)

Suitability index (SI) values for habitat parameters were derived from graphs in Figure 2 and SCS vegetation characterizations for coniferous and mixed coniferous-deciduous forest habitat types.
I = SI value for designated parameter as delineated on accompanying graphs.

Areas where SI = 0.0 for any parameter will be unsuitable for the life requisite(s) defined in any part by parameter. Suitability is low when $0.0 < I < 0.4$.

Figure 2. Graphs for determining suitability index values of parameters used to evaluate coniferous and mixed coniferous-deciduous forests for spruce grouse (adapted from USFWS 1980a).

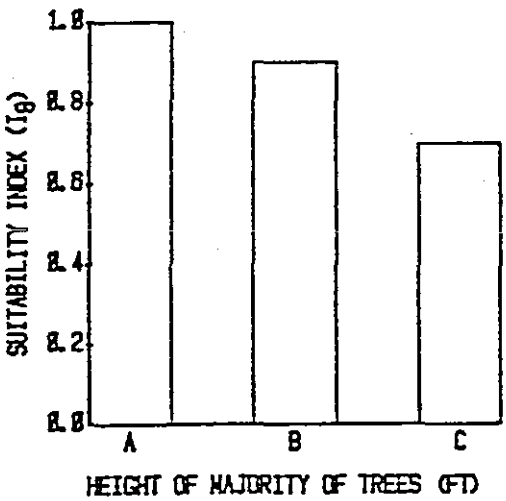


A - OPENINGS 21-30 FEET ACROSS

B - OPENINGS 31-40 FEET ACROSS

C - OPENINGS 15-20 FEET ACROSS

D - OPENINGS <15 OR >40 FEET ACROSS



A - TREES >30 FEET HIGH

B - TREES 20-30 FEET HIGH

C - TREES <20 FEET HIGH

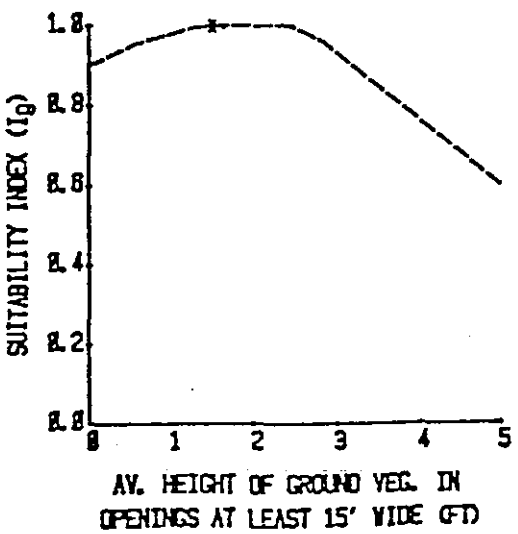
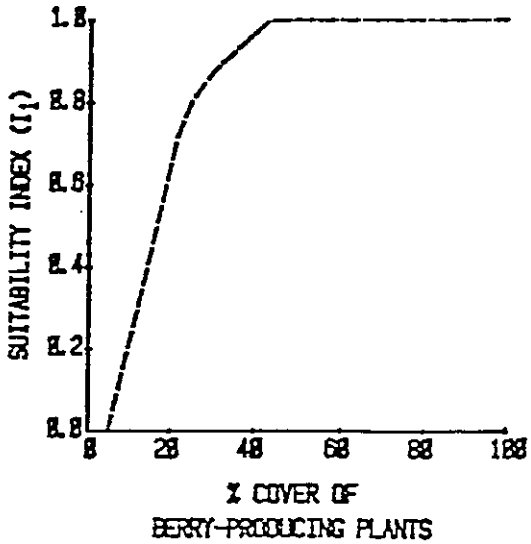
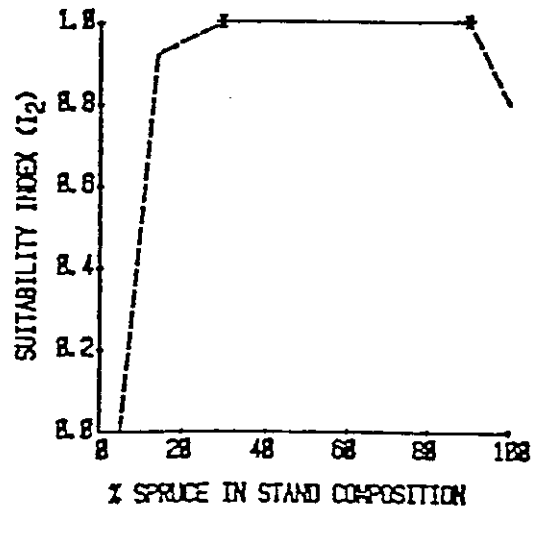
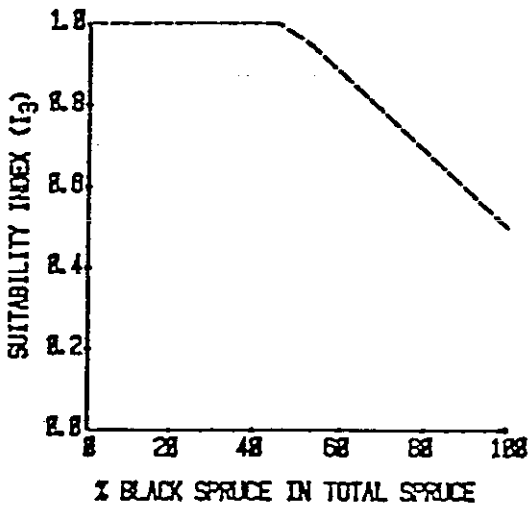
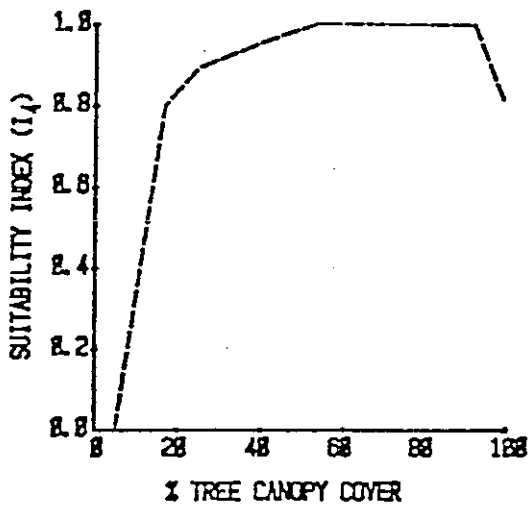


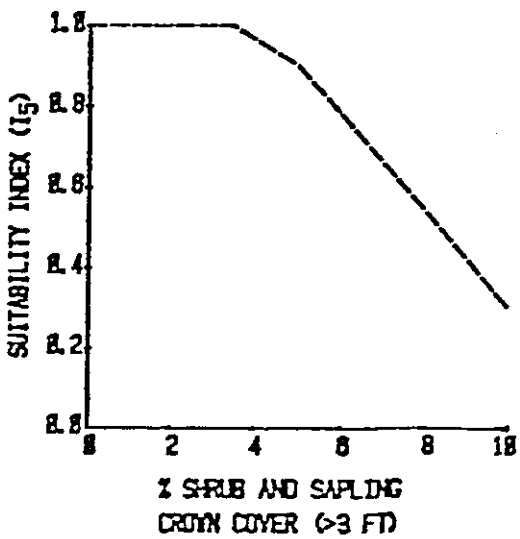
Figure 2, suitability index graphs for spruce grouse, continued.
Coniferous forests only.











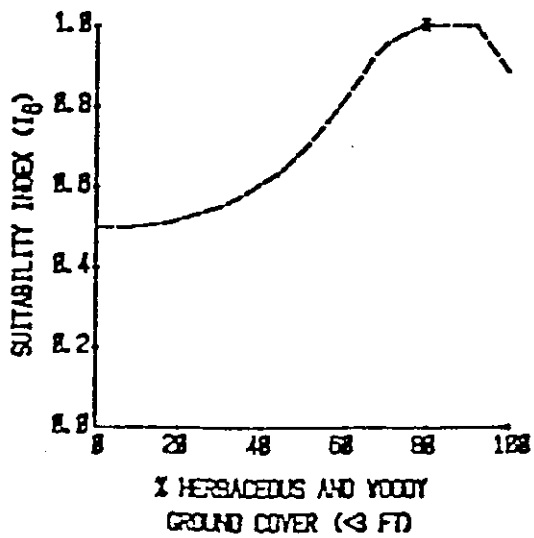
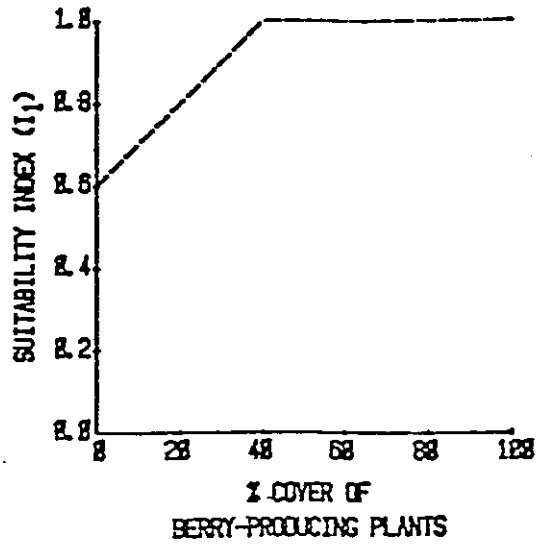
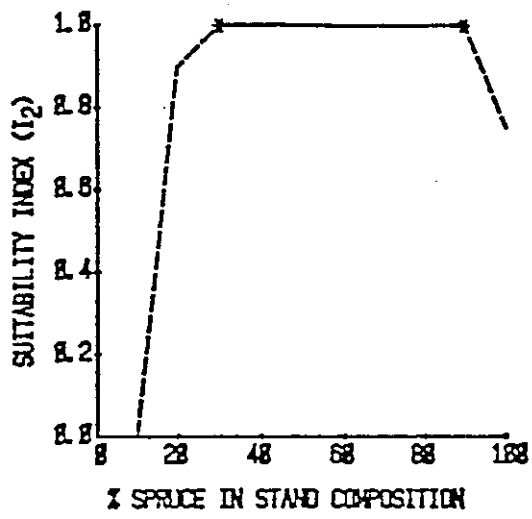
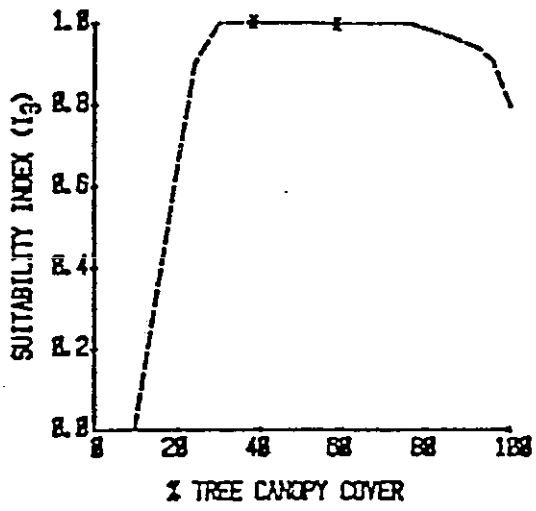
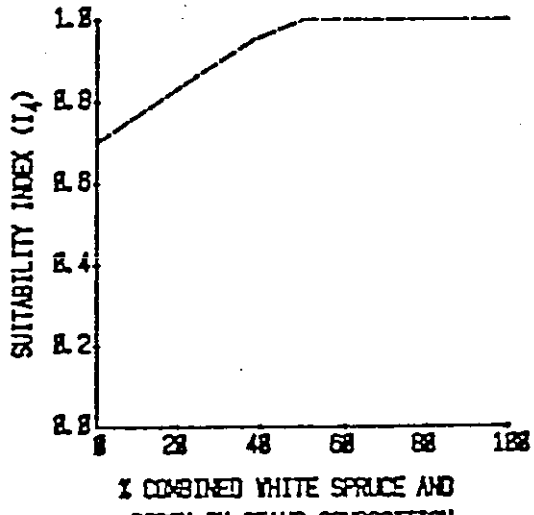


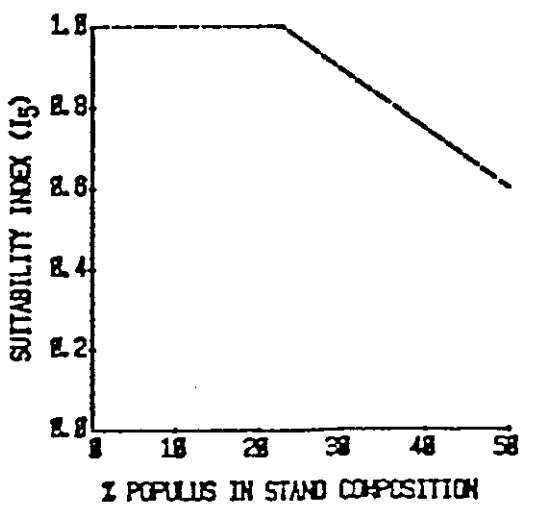
Figure 2, suitability index graphs for spruce grouse, continued.
Mixed coniferous-deciduous forests only.











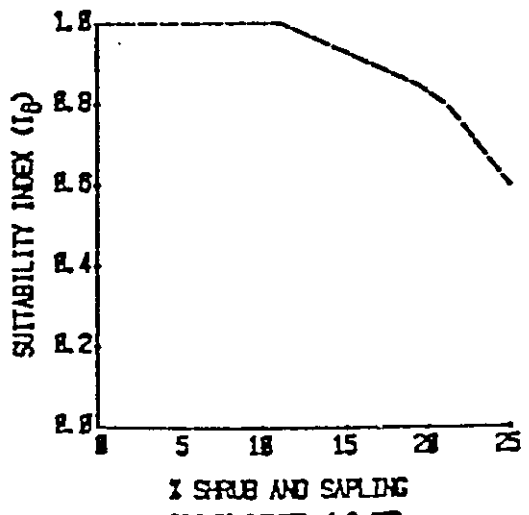


Table 9. Habitat suitability of coniferous forests for spruce grouse in the Willow Subbasin.

Life requisite: Food (spring/summer/fall)

Habitat Parameter	Habitat Type - Coniferous Forest						
	closed white spruce		open white spruce		closed black spruce		open black spruce
SCS vegetation code	short 21	tall 25	short 31	tall 33	short 41	tall 42	short 43
berry - producing plant cover = I_1 15% = M-H 5-15% = L 5% = U	L	L	L	L	H	U	H

In the mixed coniferous-deciduous forest, the suitability index (SI) for berry-producing plant cover ranged from 0.6 to 1.0. Therefore mixed forests will not be limiting for grouse food. Figure 1 was used to determine coniferous forest habitat suitability ratings as follows:

Parameter Value	Suitability Index
$I_1 \geq 0.8$	H (high)
$0.4 \leq I_1 < 0.8$	M (moderate)
$0.0 < I_1 < 0.4$	L (low)
$I_1 = 0.0$	U (unsuitable)

(Table 10). However, 7.8 percent (32,580 acres) of those forests may be considered of low value for spring/summer/fall food because berry cover is limited to from 5 to 15 percent. Another 1.5 percent (6,070 acres) are estimated to have a berry plant cover of less than 5 percent; therefore, they are unsuitable habitats for grouse spring/summer/fall food.

4. Snowshoe hare - Lepus americanus

Common and widespread throughout most of Alaska, the snowshoe hare occupies coniferous, deciduous, mixed coniferous-deciduous forests, and tall shrub habitats. Hare populations are extremely cyclic in inland areas, although less so along the coast. Hare numbers peaked most recently about 1970 then dropped to low levels in the mid-1970's. Throughout the study area, hare population levels remain moderate in localized pockets even when overall populations are at cyclic lows.

Human settlement patterns which may adversely affect hare habitat have been particularly prevalent in the Willow Subbasin: fire suppression and prevention activities in recent years have probably reduced hare habitat; urban spread and livestock grazing may cause further adverse local impacts (ADF&G 1978a). At the same time, high hare populations often alter habitat by girdling willows and other browse plants utilized by other species, such as moose.

The snowshoe hare is an important food for many furbearers, especially lynx, whose populations fluctuate in response to the hare cycle.

Hunting effort varies with population fluctuations, although hare are probably the most popular small game species in Alaska (ADF&G 1978a). Areas adjacent to roads and waterways are the most heavily hunted; these areas are also prime places for nonconsumptive observation and photography of hares.

The most important factors affecting habitat suitability for snowshoe hare are browse availability and density of cover. Study of hare habitat in interior Alaska has shown the importance of an interspersed environment which provides refuge in winter combined with more open range for summer.

Food habits of snowshoe hare vary seasonally with changes in plant species availability; locally, food habits vary with plant species density and distribution. Small twigs, bark, and conifer needles are the components of hare winter diets. Snow depth may be an important factor; deeper snows allow hares to browse at heights beyond their usual reach of approximately 24 inches. Herbaceous plants are consumed with greater frequency as their availability increases: blueberry, lowbush cranberry, fireweed, and horsetail provide food in spring. Green plants, particularly grasses, forbs, and deciduous leaves, comprise the hare's summer diet.

Crepuscular and nocturnal, the hare travels along familiar runways from shelter to feeding areas. During the day, the animal rests in slight depressions among ground litter, within dense clumps of low trees or shrubs, or under cover of rocks, logs, stumps, or vegetation bent over with snow.

(a) Snowshoe hare habitat model

Habitat suitability for snowshoe hare is described by five habitat parameters in coniferous, deciduous, and mixed coniferous-deciduous forests,

Table 10. Acres of habitat suitable or limited for spruce grouse by habitat type and life requisite.

Spruce grouse life requisites		Habitat Type: Coniferous forest	Mixed forest	Total Potential Habitat
total acres of habitat in study area (% of total)[1/]		172,010 (17.7)	243,690 (25.1)	415,700 (42.8)
Food (S/S/F)	S	133,360	243,690	377,050 (90.7)
	L	32,580	0	32,580 (7.8)
	U	6,070	0	6,070 (1.5)
Cover	S	172,010	243,690	415,700
	L	0	0	0
Reproduction	S	172,010	243,690	415,700
	L	0	0	0
Winter range	S	172,010	243,690	415,700
	L	0	0	0

S = suitable
L = limited
U = unsuitable

1/The study area also includes 437,820 acres of other habitat types, 81,820 acres of barren/disturbed land, and 34,910 acres of water. Thus the entire study area is 970,260 acres.

and four parameters in tall shrublands (Table 11). Within the Willow Subbasin, height of food plants, extent of shrub and sapling crown cover, and herbaceous and other ground cover make alder and alder-willow tall shrub habitats suitable for snowshoe hare food, cover, and reproduction (Figure 3). Values for those same parameters, as well as for tree canopy cover, indicate that mixed forest habitats of the Subbasin are also suitable for the above life requisites.

Evaluations of hare habitat parameters indicate that one of the coniferous and two of the deciduous forest types identified by SCS are of low value as hare habitat. That is, tall closed stands of black spruce typically have a shrub and sapling crown cover of less than 25 percent. This makes them of low value for hare food, cover, and reproduction; tall black spruce stands provide neither accessible winter browse nor cover from terrestrial predators. With herbaceous ground cover less than 15 percent, these spruce forests are even more limited in providing hare food.

Young and medium-aged cottonwood stands are similarly of low value for cover and reproduction; those cottonwoods associated with riparian systems also lack the herbaceous ground cover which would make them suitable habitat for hare food.

Since all SCS vegetation types which were limited for hare life requisites were also limited for various moose life requisites, they were not separately mapped. Deciduous forests identified as low value for moose winter range and winter cover are of low value for hare food. They are also limited for hare cover and reproduction when adjacent to streams or rivers. The tall black spruce stands mapped as low value for moose winter range, spring/summer/fall food, and reproduction are also of low value for hare food, cover, and reproduction.

(b) Limitations of snowshoe hare habitat model:

Errors would be introduced in the snowshoe hare habitat model if actual values for heights of food plants, extent of shrub and sapling crown covers, or percent herbaceous or total ground cover substantially differ from approximations made by SCS, U.S. Forest Service, and FWS personnel for the Willow Subbasin. Since field data from Subbasin coniferous forests had been compiled while data from other types had not, the reliability of the model is highest for coniferous forest types.

(c) Results

All 290,360 acres (30.2 percent) of mixed forest and tall shrub habitats within the Willow Subbasin are suitable for snowshoe hare food, cover, and reproduction (Table 12). However, 6,070 acres of coniferous forest and 3,390 acres of deciduous forest habitats will be of limited value for hare food, cover, or reproduction. Those areas are equal to 1.9 percent of the potential hare habitat.

5. Red squirrel - Tamiasciurus hudsonicus

Red squirrels are found in association with spruce over most of Alaska. A solitary, nonmigratory animal, the red squirrel inhabits the mature

Table 11. Parameters and rules for rating habitat suitability for three life requisites of snowshoe hare, (adapted from USFWS, 1980a).

Food Value: Limited if at least two parameters are assigned low SI's.

Where: I_1 = Suitability Index of height of cover and food plants for snowshoe hare
I_2 = SI of % shrub and sapling crown cover
I_3 = SI of % herbaceous ground cover

Cover Value: Limited if at least two parameters are assigned low SI's.

Where: I_4 = SI of % tree canopy cover (forest habitats only)
I_1 = SI of height of cover and food plants for snowshoe hare
I_2 = SI of % shrub and sapling crown cover
I_5 = SI of amount of ground cover (vegetation, rocks, stumps)

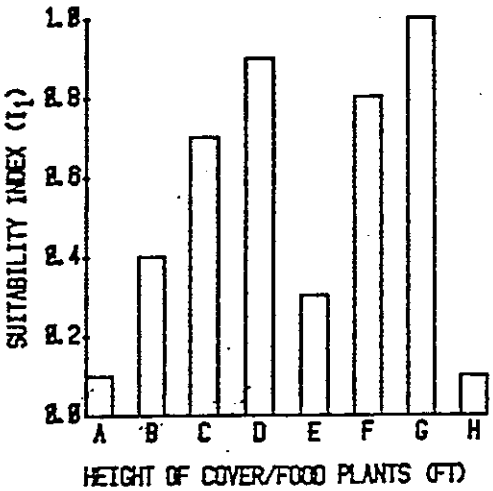
Reproductive Value: Limited if at least two parameters are assigned low SI's.

Where: I_4 = SI of % tree canopy cover (forest habitats only)
I_1 = SI of height of cover and food plants for snowshoe hare
I_2 = SI of % shrub and sapling crown cover
I_5 = SI of amount of ground cover (vegetation, rocks, stumps)

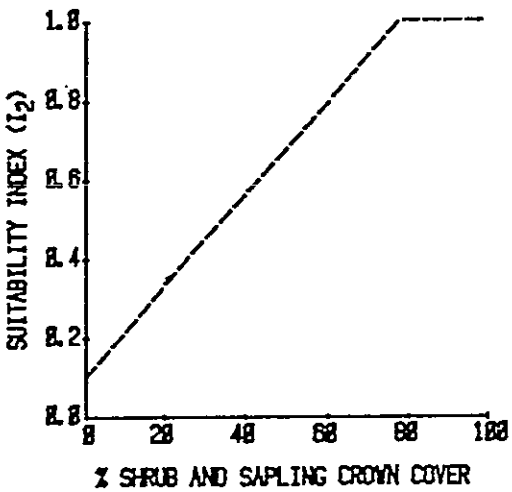
Suitability index (SI) values for habitat parameters were derived from graphs in Figure 3 and SCS vegetation characterizations for coniferous, deciduous, and mixed coniferous-deciduous forest and tall shrub types. I = SI value for designated parameter as delineated on accompanying graphs.

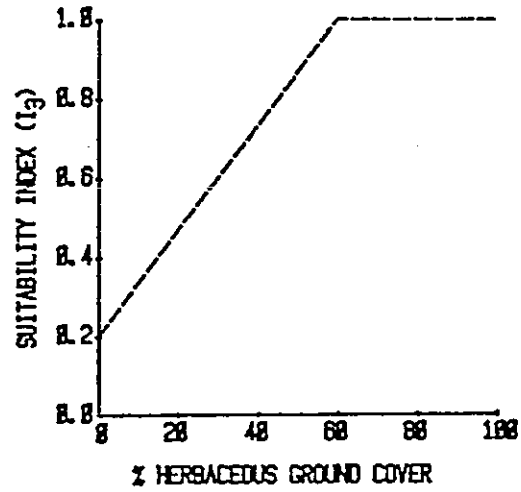
Areas where SI = 0.0 for any parameter will be unsuitable for the life requisite(s) defined in any part by that parameter. Suitability is low when $0.0 < I \leq 0.4$.

Figure 3. Graphs for determining suitability index values of parameters used to evaluate coniferous, deciduous, mixed coniferous-deciduous forests, and tall shrublands for snowshoe hare (adapted from USFWS 1980a).



A - LOW, DECUMBENT PLANT SPECIES
B - 1-3 FEET
C - 3-6 FEET BUT NOT <3 FEET
D - BOTH 1-3 FEET AND 3-6 FEET
E - 6-18 FEET BUT NOT <6 FEET
F - 6-18 FEET AND EITHER 3-6 FEET OR 1-3 FEET, BUT NOT BOTH
G - INCLUDES ALL THREE COVER RANGES; 1-3 FEET, 3-6 FEET, AND 6-18 FEET
H - MOST PLANT SPECIES >18 FEET IN HEIGHT





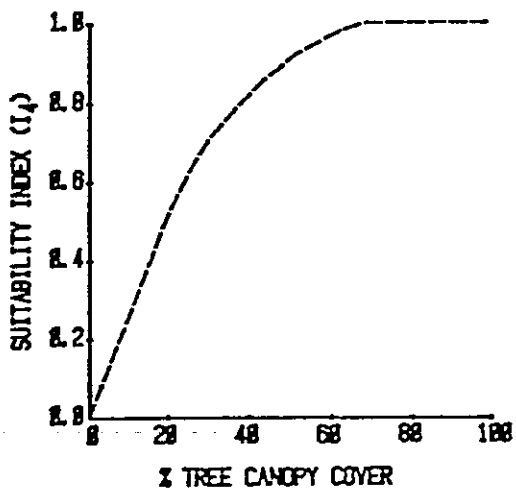
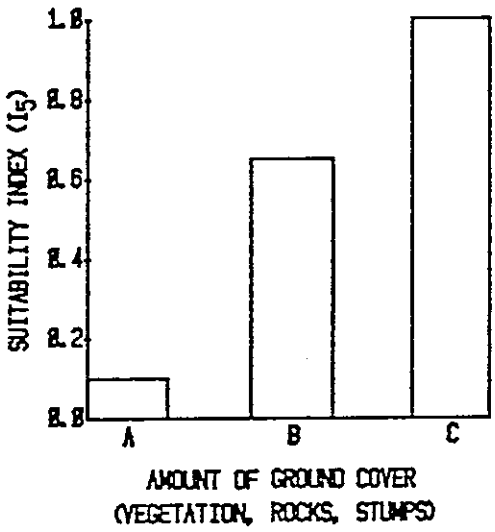


Figure 3, suitability index graphs for snowshoe hare, continued.



A - GROUND COVER (VEGETATION, ROCKS, STUMPS), <20%

B - GROUND COVER MODERATE, 20-40%

C - GROUND COVER DENSE, >40%

Table 12. Acres of habitat suitable or limited for snowshoe hare by habitat type and life requisite.

Snowshoe hare life requisites		CF	MF	DF	TS	Total Potential Habitat
total acres of habitat in study area (% of total)[1/]		172,010 (17.7)	243,690 (25.1)	35,700 (3.7)	49,670 (5.1)	501,080 (51.6)
Food, cover, or reproduction	S	165,940	243,690	32,310	49,670	491,620 (98.1)
	L	6,070	0	3,390	0	9,460 (1.9)

S = suitable

L = limited

1/Total study area also includes 352,460 acres of other habitat types, 81,820 acres of barren/disturbed land, and 34,910 acres of water. Thus the entire study area is 970,270 acres.

coniferous and mixed coniferous-deciduous forests. Although deciduous forests are utilized as marginal habitat during emigration and population expansion, they cannot support permanent overwintering populations.

Viewing and photography, especially around campgrounds, waysides, and other recreation sites, comprise significant human uses of red squirrel, one of the most commonly observed small mammals in Alaska (ADF&G 1978a). Red squirrels are primarily hunted and trapped for recreation with some utilization as food, fur, and trap bait. Some shooting of squirrels occurs around human dwellings when squirrels gain access to buildings and destroy insulation. Therefore, the widely scattered but continuing settlement of the Willow Subbasin could negatively impact squirrels in the study area. Clearcutting may also negatively impact squirrels by causing them to completely evacuate a site. Farming or ranching may destroy the forests upon which squirrels depend and result in local population displacements or reductions. Direct mortality of red squirrels also results from predation by wild carnivores such as marten, fox, lynx, and many raptors as well as by domestic animals such as dogs and cats. Alternatively, fire suppression permits development of climax forests suitable for red squirrel.

Sufficient food is believed to be the primary habitat requirement of red squirrels. White and black spruce seeds are the mainstay of red squirrel diets in Alaska, with squirrel populations fluctuating in response to spruce cone abundance. White spruce seeds are preferred over black spruce seeds and are of higher caloric value. However, the greater reliability of Alaska black spruce cone crops means that black spruce provide a more dependable and readily available food source than white spruce. From year-to-year white spruce cone crops may vary from excellent to completely nonproductive. In good years, squirrels can store more cones than necessary for overwinter survival. Stored cones, fungi, various fruits, and seeds and buds other than spruce may be important foods when cone crops fail.

(a) Red squirrel habitat model

Mature coniferous forests provide optimum squirrel cover; white spruce stands are preferred over black spruce. The comparatively high quality of white spruce stands is reflected in both smaller sizes of defended territories and higher squirrel densities in white than black spruce forests. Lower survival rates in black spruce forests are apparently due to the inferior nutritional value of black spruce cones and to the more open, less protective, nature of the overstory. The lower reproductive success of squirrels in black than in white spruce forests indicates that the overriding limiting factors for reproduction are food quality and quantity. As a result, the four parameters used to evaluate coniferous and mixed forests for red squirrel food can be used to value reproduction. Two of those parameters can be used to evaluate all forest types for squirrel cover (Table 13). In the Willow Subbasin, the percent black spruce in total spruce corresponded to at least a moderate suitability value. Moreover, the number of trees per acre was estimated to be at least 25 throughout the study area forests. Thus half the parameters used to evaluate Subbasin coniferous and mixed forests for food, cover, and reproduction received suitable values (Figure 4). However, the small tree diameters in both open and closed stands of short black spruce indicate that those types will be of low value for cover.

(a) Limitations of red squirrel habitat model

No information was available on white spruce cone production in Willow Subbasin forests. Since cone production may vary greatly from year to year, the average importance of white spruce for food and reproduction could not be determined. In years of low white spruce cone production, open and closed stands of short black spruce would probably be at least somewhat suitable as red squirrel habitat. These black spruce stands have not been specifically delineated by the squirrel habitat model.

(b) Results

Approximately 47 percent of the Willow Subbasin contains forest habitats utilized by red squirrels (Table 14). Ninety-two percent of those forests are coniferous or mixed; they are suitable for squirrel food, cover, or reproduction. However, 8 percent of the Subbasin contains deciduous forests which are of low value for any squirrel life requisite.

Table 13. Parameters and rules for rating habitat suitability for three life requisites of red squirrel, (adapted from USFWS 1980a).

Food Value: Limited if at least two of the following parameters are assigned low SI's.

Where: I_1 = Suitability Index of % coniferous in total trees (mixed forests only)
I_2 = SI of % black spruce in total spruce (coniferous and mixed forests only)
I_3 = SI of number of trees per acre
I_4 = SI of average DBH of trees (inches)
I_5 = SI of white spruce cone production
I_6 = SI of % quaking aspen in total trees (deciduous forests only)

Cover Value: Limited if at least one of the following parameters is assigned a low SI.

Where: I_3 = SI of number of trees per acre
I_4 = SI of average DBH of trees (inches)

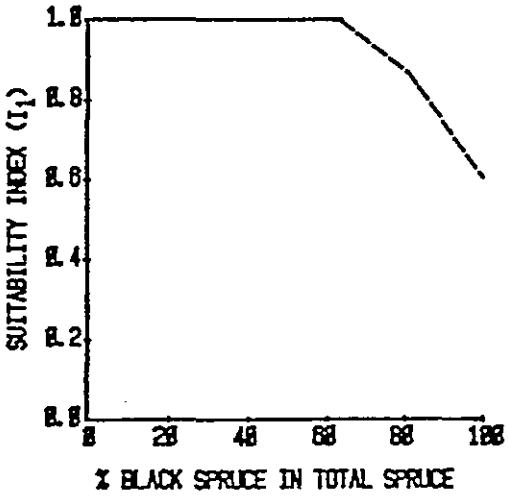
Reproductive Value: Limited if at least two of the following parameters are assigned low SI's (not evaluated for deciduous forests)

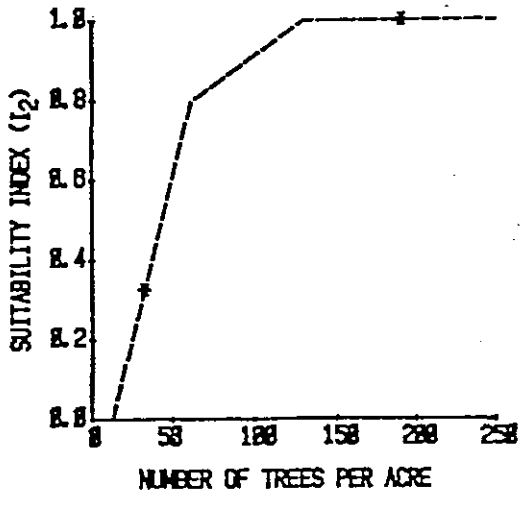
Where: I_1 = SI of % coniferous in total trees (mixed forests only)
I_2 = SI of % black spruce in total spruce
I_3 = SI of number of trees per acre
I_4 = SI of average DBH of trees (inches)
I_5 = SI of white spruce cone production

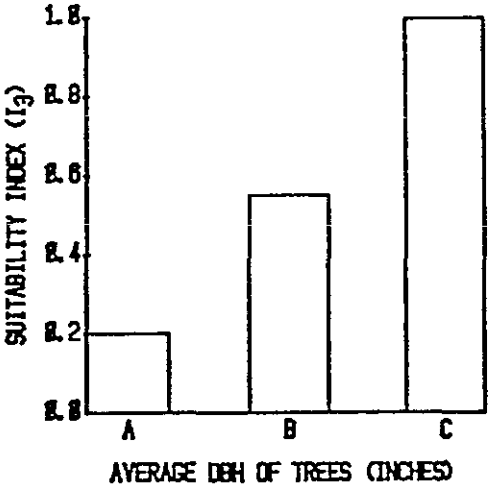
Suitability index (SI) values were derived from graphs in Figure 4 and SCS vegetation characterizations for coniferous, deciduous, and mixed forests. I = SI value for designated parameter as delineated on accompanying graphs.

Areas where SI = 0.0 for any parameter will be unsuitable for the life requisite(s) defined in any part by that parameter. Suitability is low when 0.0 I 0.4.

Figure 4. Graphs for determining suitability index value of parameters used to evaluate for red squirrel (adapted from USFWS 1980a).



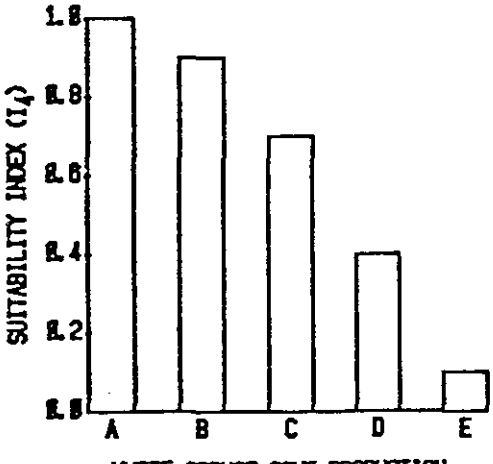




A - DBH <5 INCHES

B - DBH 5 TO 11 INCHES

C - DBH >11 INCHES



A - >500 CONES ON 75-100% OF TREES; 100-500 CONES ON ALL TREES

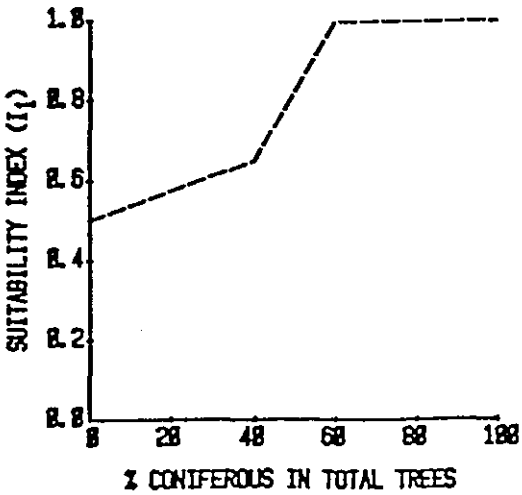
B - >500 CONES ON 50-75% OF TREES; 100-500 CONES ON ALL TREES

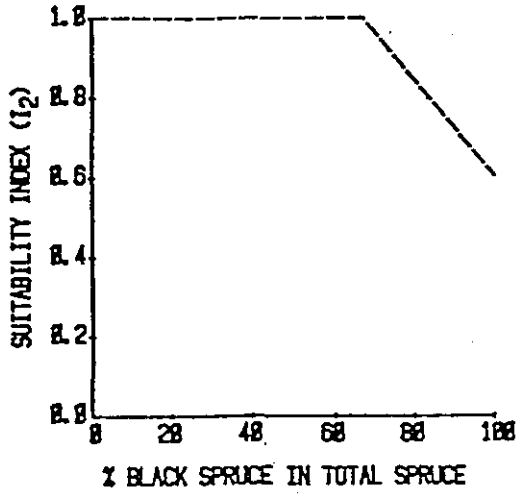
C - <100 CONES ON 50-75% OF TREES; >500 CONES ON SOME TREES

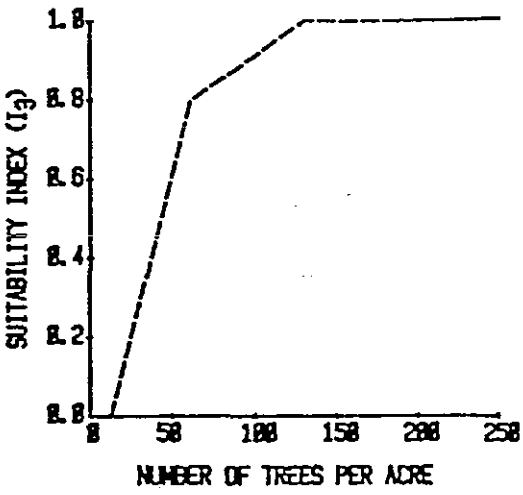
D - <100 CONES ON 75-85% OF TREES; >500 CONES ON OCCASIONAL TREES

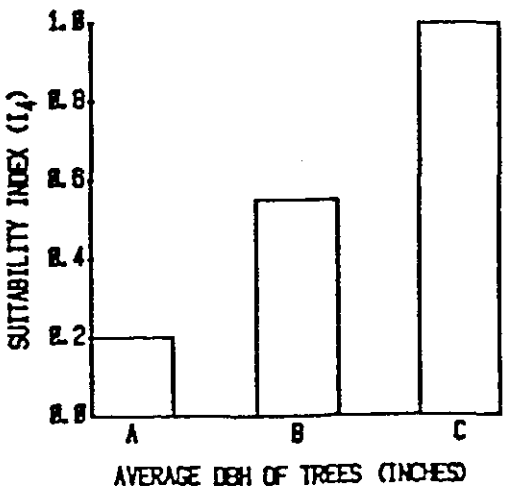
E - <100 CONES ON OCCASIONAL TREES; OR NO CONES ON ANY TREES

Figure 4, suitability index graphs for red squirrel, continued.
Mixed coniferous-deciduous forests only.







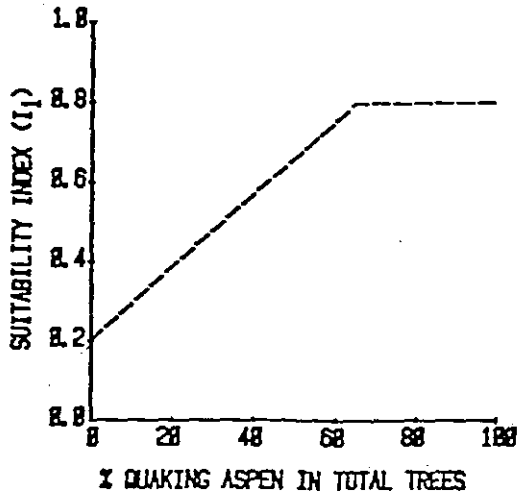


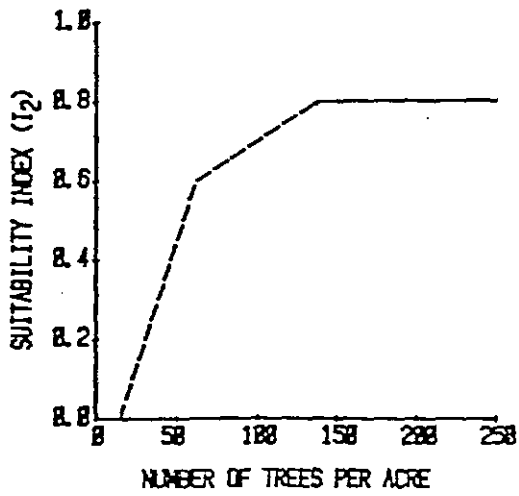
A - DBH <5 INCHES

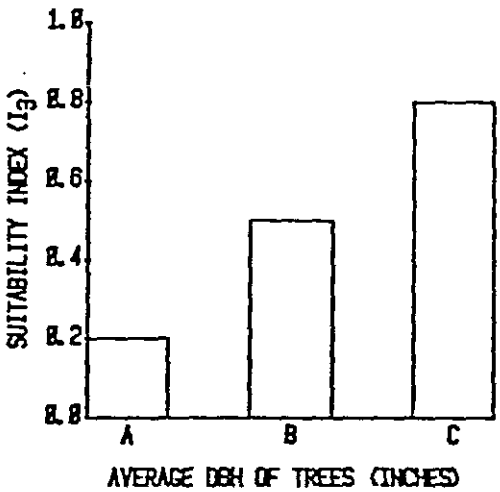
B - DBH 5 TO 11 INCHES

C - DBH >11 INCHES

Figure 4, suitability index graphs for red squirrel, continued.
Deciduous forests only.







A - DBH <5 INCHES

B - DBH 5 TO 11 INCHES

C - DBH >11 INCHES

Table 14. Acres of habitat suitable for red squirrel by habitat type and life requisite.

Red squirrel life requisites		Habitat type: Coniferous Forest	Mixed Forest	Deciduous Forest	Total Potential Habitat
total acres of habitat in study area (% of total)[1/]		172,010 (17.7)	243,690 (25.1)	35,700 (3.7)	451,410 (46.5)
Food or Cover	S	172,010	243,690	0	415,700 (92.1)
	L	0	0	35,700	35,700 (7.9)
Reproduction	S	172,010	243,690	--	415,700 (92.1)
	L	0	0		0 (0)

S = suitable
L = limited

--habitat not evaluated for this life requisite

1/The study area also includes 302,790 acres of other habitat types, 81,820 acres of barren/disturbed land, and 34,910 acres of water. Thus, the entire study area is 970,260 acres.

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FOREST & WOODLAND (> 10% Crown Cover)

CLOSED FOREST (< 50% Crown Cover)

CONIFEROUS FOREST White Spruce

Code

21 Short stands white spruce - Main canopy usually less than 30 feet in height, usually found at higher elevations as isolated pockets in areas dominated by alder, grassland or open mixed stands.

Characteristic plants are: Trees - white spruce, paper birch; Shrubs - willows, high bush cranberry, prickly rose alder, rusty menziesia; Herbs - fireweed, dogwood, starflower; Grasses - bluejoint; Others - sedges, ferns.

Total annual production of the understory is:
1000 - 1500 lbs/acre

25 Tall stands white spruce - Main canopy usually greater than 30 feet in height, usually found at lower elevations on better sites, almost always found mixed with old and decadent deciduous trees (very rarely found as a pure type in Susitna Valley).

Characteristic plants are: Trees - white spruce, paper birch; Shrubs - willow, blueberry, dwarf birch, spirea; Herbs - fireweed, dogwood, five-leaf bramble, lupine; Grasses - bluejoint; Others - ferns.

Total annual production of the understory is:
400 - 650 lbs/acre

Black Spruce

41 Short stands black spruce - Main canopy usually less than 30 feet in height, generally found on wet and/or cold (poor) sites, may be found mixed with birch of poor quality but usually found as a pure type forming islands and stringers in bog areas or transition zones between bog area and forest areas. Understory is usually a thick moss and/or sedge mat.

Characteristic plants are: Trees - black spruce, paper birch; Shrubs - willows, spirea, lowbush cranberry, dwarf birch, labrador tea, crowberry, twin-flower; Herbs - wintergreen; Grasses - bluejoint; Others - horsetails.

Total annual production of the understory is:
150 - 400 lbs/acre

42 Tall stands black spruce - Main canopy usually greater than 30 feet in height, can usually be identified as a fire formed stand, on relatively good sites, stands are remarkably pure and the stocking density is usually quite high, may be found mixed with very scattered birch.

Characteristic plants are: Trees - black spruce, paper birch; Shrubs - lowbush cranberry, blueberry, dogwood, crowberry, labrador tea, currant, highbush cranberry, prickly rose, twin-flower, geocaulon; Grasses - bluejoint; Others - horsetails.

Total annual production of the understory is:
100 - 300 lbs/acre

Mountain Hemlock

*45 Short stands hemlock - Main canopy less than 30 feet, geographically limited in Susitna Valley to higher ground west of Tyonek, found as stringers mixed with other local types.

*46 Tall stands hemlock - Main canopy greater than 30 feet, geographically limited in Susitna Valley to low ground west of Tyonek, found as stringer stands mixed with other local types.

Deciduous Forest - Closed deciduous, Closed mixed

22 Young stand - deciduous/mixed - Canopy is usually very finely textured as seen from above, openings in stand are very rare. Composed mostly of birch and/or aspen. This type very rarely mixed with other types except when found as a remnant condition in burned areas. Spruce is not usually evident as a component of the overstory in these young stands. 0-40 years old.

Characteristic plants are: Trees - paper birch, aspen; Shrubs - willows, alders, prickly rose, lowbush cranberry, rusty menziesia, highbush cranberry, dogwood, twin-flower, devilsclub, spirea; Grasses - bluejoint; Herbs - cloudberry, starflower; Others - horsetails, lichens.

Total annual production of the understory is:
400 - 700 lbs/acre

24 Medium age stand - deciduous/mixed - Canopy is usually fine textured as seen from above, openings may be fairly common but they are usually small. Elements of this type include birch, spruce and aspen. Birch is usually found as a main component of this type but % composition may vary greatly depending on a number of factors, e.g., as the type increases in age, the percentage of white spruce as a grown component usually increases along with the amount of understory and number of stand openings. 40-100 year age.

* Note these descriptions are very tentative. (These types were not present in the Willow Subbasin.)

Characteristic plants are: Trees - paper birch, white spruce, black spruce, aspen; Shrubs - alders, willows, highbush cranberry, lowbush cranberry, prickly rose, labrador tea, American red raspberry, bog blueberry, rusty menziesia, devilsclub; Herbs - dogwood, starflower, fireweed; wintergreen, tall bluebell, cloudberry; Others - horsetails, ferns.

Total annual production of the understory is:
200 - 1000 lbs/acre

26 Old stand - deciduous/mixed - Canopy is usually somewhat coarse textured as seen from above, openings are usually common and may cover close to half of the stand area. Canopy may also appear smooth, but openings appear as definite holes in the crown. Deciduous trees in these old stands are usually decadent. Spruce is usually becoming the dominant species. The understory component of the stand is usually visible from above and includes Calamagrostics and Alnus as its most common species. These stands are always greater than 100 years old.

Characteristic plants are: Trees - paper birch, white spruce, black spruce; Shrubs - alders, tall blueberry, rusty menziesia, prickly rose, lowbush cranberry, highbush cranberry, devilsclub, five-leaf bramble, twin-flower; Grasses - bluejoint; Others - horsetails, ferns.

Total annual production of the understory is:
400 - 1500 lbs/acre

Cottonwood

27 Young stands - cottonwood - Most commonly found on new islands, downstream ends of old islands and point bars of rivers. Cottonwood or poplar is usually found mixed with large alder and/or willow - (understory is sparse to nonexistent). 40 years old.

Characteristic plants are: Trees - cottonwood; Shrubs - willows, alders; Grasses - bluejoint; Others - horsetails, ferns.

Total annual production of the understory is:
100 - 300 lbs/acre

28 Medium age stands - cottonwood - Most commonly found in a riverine situation or within at least one mile of a river (alluvial soils): Stands are usually pure cottonwood or poplar, spacing is even and crown closure approaches 100%. Understory in the Susitna Valley is dominated by alder and devilsclub. 40-100 years old.

Characteristic plants are: Trees - cottonwood, white spruce; Shrubs - devilsclub, highbush cranberry, alders, willows, American red raspberry; Grasses - bluejoint; Others - horsetails, ferns.

Total annual production of the understory is:
600 - 1000 lbs/acre

29 Old stands - cottonwood - Most commonly found in riverine influence (alluvial soils). Stands may be mixed with young white spruce. Cottonwood are extremely large (30-40 inches in diameter) and decadent (larger trees may be only shells). Stand appears somewhat clumpy due to openings appearing in stand. Understory includes large quantities of alder, devilsclub and willow. Greater than 100 years old.

Characteristic plants are: Trees - cottonwood, white spruce; Shrubs - alders, willows, prickly rose, devilsclub, highbush cranberry, American red raspberry; Grasses - bluejoint; Others - ferns, horsetails.

Total annual production of the understory is:
700 - 1100 lbs/acre

OPEN FOREST - WOODLAND (10-50% Crown Cover)

Coniferous Forest White Spruce

31 Short stands - white spruce - Usually found at higher elevations as a transition type between closed forest and high elevation nonforest areas. Usually found mixed with elements of the higher elevation type, i.e., if the higher elevation type is a mixture of alder and grass then the open white spruce transition type will normally be forming a complex type with alder and grass. 30 feet tall.

Characteristic plants are: Trees - white spruce, paper birch; Shrubs - alders, willows, American red raspberry, dwarf birch; Grasses - bluejoint, bromes; Herbs - starflower, dogwood, cow parsnip, false hellebore; Others - ferns, horsetails.

Total annual production of the understory is:
1200 - 2000 lbs/acre

33 Tall stands - white spruce - Same as type 31 except normally found at lower elevations or on better sites. Commonly found in creek bottoms mixed with alder/willow and grass. 30 feet tall.

Characteristic plants are: Trees - white spruce, paper birch; Shrubs - alders, willows, lowbush cranberry, twin-flower, labrador tea, spirea; Grasses - bluejoint; Herbs - dogwood, starflower; Others - ferns, horsetails.

Total annual production of the understory is:
300 - 700 lbs/acre

Black Spruce

43 Short stands - black spruce - Found in association with bog types. Black spruce are usually of very poor form. Site is either wet or cold or both - trees usually less than 15 feet in height.

Characteristic plants are: Trees - black spruce, paper birch; Shrubs - dwarf birch, labrador tea, bog blueberry, bog rosemary, crowberry, alders, willows; Grasses - bluejoint; Herbs - dogwood, geocaulon, cloudberry; Others - sedges, horsetails.

Total annual production of the understory is:
300 - 900 lbs/acre

Deciduous Forest Open deciduous, Open mixed

32. Medium Age stands - deciduous mixed - Similar to type 31 except normally found at lower elevations (as elevation increases so does proportion of spruce in mixed types). Although birch/aspen stands are not usually found as a transition type between forest and high elevation nonforest areas, they are often found just below areas of type 31. 40 years old.

Characteristic plants are: Trees - paper birch, white spruce; Shrubs - dwarf birch, alder, prickly rose, highbush cranberry, willow, sweetgale, leatherleaf, rusty menziesia; Grasses - bluejoint; Herbs - cloudberry, fireweed, bunchberry; Others - ferns, horsetails.

Total annual production of the understory is:
1000 - 1800 lbs/acre

34 Old stands - Found in same general location as type 33. Found in association with grass and alder. Birch, in this type, is usually found growing in very small, tight clumps. Spruce are usually found to have an open grown form and are normally much younger than the hardwood component of the type.

Characteristic plants are: Trees - paper birch, white spruce; Shrubs - alders, willows, highbush cranberry, rose, devilsclub, elderberry, tall blueberry; Grasses - bluejoint; Herbs - fireweed, dogwood, burnet, false hellebore, starflower, bluebell; Others - ferns, horsetails.

Total annual production of the understory is:
800 - 1500 lbs/acre

Cottonwood

*35 Medium Age stands - Usually found at treeline just above elevational limit of open white spruce. Found in pockets among low shrubs.

Characteristic plants are: Trees - cottonwood, white spruce; Shrubs - alder, willow, devilsclub; Grasses - bluejoint; Herbs - wintergreen, fireweed, bluebell; Others - ferns, horsetails.

Total annual production of the understory is:
400 - 1000 lbs/acre

*36 Old stands - Two elevational phases of this type seem to occur. The high elevation phase, consisting of balsam poplar, may be found mixed with streamside alder/willow along flowing water on high elevation flats. The low elevation phase, consisting of cottonwood, may be found on major river flood plains growing with a confusing mixture of other types including open spruce, open birch, alder, grass, etc.

Characteristic plants are: Trees - cottonwood, birch, white spruce; Shrubs - alders, willows, rose, highbush cranberry, American red raspberry, devilsclub; Grasses - bluejoint; Others - ferns, horsetails.

Total annual production of the understory is:
700 - 1300 lbs/acre

NON FOREST (<10% Crown Cover)

Saltwater Wetlands

*50 Grassland - Elymus dominated grassland in areas of tidal influence. Usually found at edge of normal high water in sandy soil. Normally this type is found in areas where the shoreline gradient is relatively steep, usually found as a belt of grass along the shore.

Total annual production of the understory is:
800 - 1500 lbs/acre

*51 Low shrub - Myrica dominated shrubland located on tidal flats. Water level is usually fluctuating seasonally. In areas that are more continuously wet, sedge replaced Myrica.

Total annual production of the understory is:
200 - 800 lbs/acre

*52 Tidal Marsh - Usually found in areas with many shallow lakes and little topographic relief (within tidal influence). Vegetation is dominated by various sedges. Woody plants may occur on the drier sedge and peat ridges that are common to this type.

Total annual production of the understory is:
400 - 1300 lbs/acre

Tall Shrub

*60 Alder - This type is dominated by tall (10-15 feet) alder growing in dense thickets with grasses, ferns, and a great variety of forbs growing in the understory. Devilsclub can be found as a dominant understory to the alder on wetter and steeper sites. Devilsclub will normally exclude other understory vegetation. The type is found at or above treeline. At treeline it is often found mixed with open white spruce and cottonwood types.

Characteristic plants are: Trees - white spruce, cottonwood; Shrubs - alder, devilsclub, spirea, currant; Grasses - bluejoint, bentgrass; Herbs - fireweed; Others - ferns, horsetails.

Total annual production of the understory is:
2000 - 3000 lbs/acre

*61 Alder-Willow (streamside vegetation) - This type is dominated by a mixture of very large alder and willow. This type is normally found on frequently flooded ground such as new islands, point bars, etc. Understory is sparse but may include equisetum and calamagrostis. This type is often found mixed with young open cottonwood (in younger stands the cottonwood is almost indistinguishable from the willow and alder).

Characteristic plants are: Trees - cottonwood; Shrubs - aders, willows, rose; Herbs - bluebells, lupines, fireweed; Grasses - bluejoint; Others - horsetails, ferns, sedges.

Total annual production of the understory is:
500 - 1500 lbs/acre

Low Shrub

*62 Willow - resin birch - This type is dominated by either willor or resin birch or a combination thereof. The type is often found in sheltered situations at high elevations, e.g., draws in mountainous terrain. This type is found at and above the transition between tall shrubland and tundra.

Characteristic plants are: Shrubs - dwarf birch, willows, tall blueberry, Grasses - bluejoint, bentgrass; Herbs - fireweed, lupines, meadowrue; Others - ferns, sedges.

Total annual production of the understory is:
750 - 1000 lbs/acre

Grass land

*63 Calamogrostis grassland - This type is dominated by Calamagrostics 1 to 2 meters tall. Fireweed and various ferns are sometimes common. This type is most often found as an understory in the more open forest types and woodland areas where it is commonly associated with alder patches. This type can also be found unassociated with other types along small streams.

Characteristic plants are: Trees - white spruce, birch, cottonwood; Shrubs - alder, American red raspberry; Herbs - fireweed, cow parsnip, false hellebore; Grasses - bluejoint; Others - ferns, sedges.

Total annual production of the understory is:
2500 - 3500 lbs/acre

Tundra

*64 Sedge - Grass Tundra - This type is found above treeline on relatively flat, wet areas. Vegetation consists almost entirely of various wet sedges.

Characteristic plants are: Shrubs - willows; Grasses - bluejoint, bentgrass; Others - sedges.

Total annual production of the understory is:
200 - 800 lbs/acre

*65 Herbacious Tundra - This type is found above treeline and is almost always found mixed with and above shrub tundra. The variety of species found in this type is immense, consisting mainly of various grasses and forbs. Soil varies in depth and may be intermixed with rock outcroppings. Vegetation may not be continuous.

Characteristic plants are: Shrubs - tall blueberry, dwarf birch, crowberry, willows, bearberry; Herbs - geranium, wintergreen, fireweed, dogwood; Grasses - brome, fescue, timothy; Others - sedges.

Total annual production of the understory is:
300 - 800 lbs/acre

*66 Shrub Tundra - This type is dominated by dwarf arctic birch and other shrubs along with various short grasses and a large number of forbs. This type is almost always found mixed with and below herbacious tundra. Density of the shrubs found in this type varies considerably and may often appear quite patchy.

Characteristic plants are: Shrubs - willows, dwarf birch, alder, labrador tea, tall blueberry, bearberry, burnet, wintergreen; Grasses - bluejoint, fescue, timothy, hairgrass; Others - sedges, ferns.

Total annual production of the understory is:
500 - 1200 lbs/acre

*67 Mat-cushion tundra - This type is dominated by such plants as dryas, crowberry, bearberry, sedge, grass, lichen and other rooted forbs. Climatic conditions are extreme at the elevation where this type is found. Vegetation cover may be complete (closed mat cushion) or relatively sparse (scattered mat cushion) with a large percentage of the vegetation being lichen. This type is often mixed with rock.

Total annual production of the understory is:
50 - 100 lbs/acre

Fresh Water Wetlands

*68 Sphagnum bog - Cover is dominated by varying amount of sedge, equisetum and moss (especially sphagnum). This type is usually found as a floating mat over several feet of water or as a thick mat directly over saturated or frozen soil. Shrubs and stunted trees (if present) may be found on drier peat ridges. (This type is similar to tidal marsh except that shallow lakes are less common, the peat ridges form a more continuous and regular pattern and the type is found inland beyond tidal reach. Usually found as a pure type.

Characteristic plants are: Trees - black spruce; Shrubs - dwarf birch, bog blueberry, sweetgale; Herbs - cloudberry, buckbean; Grasses - bluejoint; Others - sedges, cottongrass.

Total annual production of the understory is:
300 - 600 lbs/acre

*69 Sphagnum/Shrub bog - Vegetation of this type is dominated by a thick moss mat (sphagnum) and/or sedge tussocks. Grass, ericaceous shrubs, salix, blueberry and cranberry may also be present. Ground water level usually varies seasonally but this type is usually never as wet as sphagnum bog. This type is usually mixed with open stands of short black spruce. Many other types may also be found in close association with sphagnum shrub bog. The associated types are usually found on glacial moraines and eskers within the bog area.

Characteristic plants are: Trees - black spruce; Shrubs - dwarf birch, labrador tea, leatherleaf, willows, lowbush cranberry, bog rosemary, sweetgale; Herbs - cloudberry, buckbean; Grasses - bluejoint; Others - sedges, horsetails, cottongrass.

Total annual production of the understory is:
500 - 1200 lbs/acre

NON VEGETATED

*70 Cultural influence - May be broadly defined as land that has been obviously affected by human activity. Includes agricultural land, urban areas, and land developed to support or provide services to agricultural and urban land. This "type" may indeed be vegetated but vegetation that is present may not be natural in either composition or spacing.

Barren

*80 Mud Flats - Confined to tidal areas (Cook Inlet...) and the mouths of major rivers (Susitna, Knik...). This "type" may appear vegetated on C.I.R. and color photography or from the air, however, the "vegetation" is usually algal blooms, and/or other sea plants. Mud flats are usually well patterned with ripple marks or water drainage pattersn. They are normally submersed during high tide. They may be used as resting and feeding areas by waterfowl.

*81 Rock - Includes exposed bedrock and scree commonly found along with mat cushion tundra at high elevations. This "type" is also used to describe large landslide areas - some morainal features and other natural barren areas.

Permanent Snow and Ice

*82 Snow fields - High elevation snow accumulation areas. Appears to be a permanent or nearly year round part of the landscape. May be found as small pockets on slopes protected from the sun, on lee slopes or in gulleys. Usually found over bare ground. May also be found as large snow accumulation areas at very high elevations. Often mixed with mat-cushion tundra and rock.

*83 Glacier - Includes both icefields and glaciers. Usually found covering several square miles. Considered a permanent part of landscape. To differentiate 83 from 82, note 83 covers much larger areas; crevasses, moraines and other glacial features are usually present.

Revised Moose HEP* Model

Description of Model

The suitability of the Talkeetna and Beluga Subbasins as moose habitat was modeled with regard to winter range (WR) and spring/summer/fall range (S/S/FR). Range was defined as areas which provide moose with their life requisites of food and cover for the season(s) of interest. Two other essential life requisites which must be provided if habitat is to satisfy all needs of a moose during its life cycle are reproduction and interspersion. Because data on which to base a reliable model of reproductive habitat does not exist, no such model was prepared. Interspersion was considered manually after each seasonal range was mapped. Interspersion is defined as suitable if both WR and S/S/FR are provided within the potential home range of moose. Thus the absence or low value of any one life requisite will seriously limit overall habitat suitability.

The suitability of Subbasin vegetation types as moose winter range was based upon four parameters: quality of deciduous browse species, quantity of deciduous browse species, presence of Vaccinium vitis-idaea, and canopy cover. The first three parameters were used to indicate food value, the last one to indicate cover value, primarily for protection from weather. Only forest and tall shrubland vegetation types were evaluated as potential WR.

* HEP = Habitat Evaluation Procedures

Four parameters were also used to evaluate Subbasins for their suitability as spring/summer/fall range: quality of deciduous browse species, quantity of deciduous browse species, forb quantity, and proximity to cover. Again, the first three parameters provided an index of food value, the fourth parameter was an index of cover value, primarily for protection from predators. While all Subbasin vegetation types were evaluated as potential S/S/FR, a few types were found to be unsuitable.

The parameters for defining each seasonal range were combined and criteria for assigning Suitability Index (SI) values were applied as follows:

$$\text{SI for WR} = \frac{2(V_1) + V_2 + V_3}{4} + V_4$$

$$\text{SI for S/S/FR} = \frac{2(V_1) + V_2 + V_5 + V_6}{5}$$

where:

V_1 = deciduous browse quality as indicated by species and percent of total available browse.

V_2 = deciduous browse quantity as indicated by total available browse of Salix, Betula, and Alnus species.

V_3 = availability of cover as indicated by canopy type and percentage of tall shrub cover.

V_4 = presence of Vaccinium vitis-idaea (VAVI) according to percentage of cover: a = $>$ 5%, b = 1-5%, c = $<$ 1%.

V_5 = availability of cover as indicated by canopy type or distance to forest and to all shrub cover types.

V_6 = total annual forb production.

The suitability of each vegetation type as moose habitat was independently determined for WR and S/S/FR, resultant values were considered together in assigning overall habitat values for each type. Values of each parameter within each vegetation type, as well as calculated SI's for each vegetation type, are shown in the following tables.

Table 1:
Criteria for assigning SI values to moose habitat parameters

Parameters	SI Value
V_1 = SI value of dominant deciduous browse, by percent of total available browse (WR) or annual production (S/S/FR)1/	
a. *Salix* $\geq$ 80%	0.9
b. *Betula papyrifera* $\geq$ 80%	0.9
c. *Salix* + *Betula* + *Alnus* where 50% $\leq$ *Alnus* $<$ 65% and *Salix* and *Betula* are each at least 15%	0.9
d. *Salix* + *Alnus* where 60% $\leq$ *Salix* $<$ 80%	0.8
e. *Salix* + *Betula* where 40% $\leq$ *Salix* $<$ 80%	0.8
f. *Salix* + *Alnus* where 25% $\leq$ *Salix* $<$ 60%	0.7
g. *Salix* + *Betula* + *Alnus* where 75% $<$ *Alnus* $\leq$ 80% and *Salix* and *Betula* are each at least 10%	0.7
h. *Betula nana* + *Salix* + *Alnus* where *Salix* $<$ 10% and *Betula nana* $\geq$ 60%	0.6
i. *Betula nana* $\geq$ 80%	0.6
j. *Betula* + *Salix* + *Alnus* where *Salix* $<$ 10% and 10% $\leq$ *Betula* $<$ 40%	0.5
k. *Alnus* + *Salix* or *Alnus* + *Salix* + *Betula* where 90% $\leq$ *Alnus* $<$ 95%	0.3
l. *Alnus* $>$ 95%	0.2

1/ Available browse as defined by SCS included stems and twigs less than 5mm in diameter and was used here as an index of winter browse availability. Leaves and twigs comprising the current year's growth were measured for SCS figures on annual production, the index for spring/summer/fall browse availability. For further details on methods of data collection and definitions of terms see: *Preliminary Field Procedures for the Cooperative Vegetation Inventory of the Susitna River Basin, Alaska*, Pacific Northwest Forest and Range Experiment Station, Alaska Renewable Resources Evaluation Project (RRE-4103), April, 1979.

V_2 = Total available browse for WR or total annual production for S/S/FR in pounds per acre of *Salix*, *Betula*, and *Alnus* spp.	
a. $\geq$ 575	1.0
b. 300 $\leq$ browse $<$ 575	0.8
c. 100 $\leq$ browse $<$ 300	0.6
d. 50 $\leq$ browse $<$ 100	0.4
e. 20 $\leq$ browse $<$ 50	0.2
f. 0 $<$ browse $<$ 20	0.1
g. 0	0.0

V_3 = Cover for WR as measured by tree canopy cover in forest types and by percent tall shrub cover in tall shrublands.

a.	closed forest by type and ground verification of plots so classified by photo-interpretation	
	CF or MF	1.0
	DF	0.8
b.	closed forest by type but where ground verification of plots so classified by photo-interpretation showed cover to be less than 50%	
	CF or MF	0.8
	DF	0.6
c.	open forest by type but ground verification of those plots showed canopy cover to be at least 50%	
	CF or MF	0.8
	DF	0.6
d.	open forest by type and ground verification showed canopy cover to be 10 to 50% for plots so classified by photo-interpretation	
	CF or MF	0.6
	DF	0.4
e.	shrub canopy cover > 4.5 feet for tall shrublands	
	50% cover	.8
	10 to 50% cover	.4

Definitions: CF = coniferous forest
MF = mixed forest
DF = deciduous forest
closed = at least 50% canopy cover
open = between 10 and 50% canopy cover

V_4 = Vaccinium vitis-idaea cover.1/

a.	greater than 5% average cover	0.06
b.	1 to 5% average cover	0.03
c.	less than 1% average cover	0.00

1/ Vaccinium vitis-idaea is not essential winter browse but is utilized in winter. Therefore Vaccinium presence was counted as a bonus; absence of this Vaccinium was not used to downgrade the SI calculated for WR with regard to each vegetation type.

V_5 = Cover for S/S/FR as measured by vegetation type or distance to vegetation types which supply cover

a.	CF, MF, DF, or TS	1.0
b.	portions of all other vegetated types when within 440 yards of CF, MF, DF, or TS; S/S/FR value is based solely on food parameters.	0
c.	portions of all other vegetated types when farther than 440 yards from CF, MF, DF, or TS	0

V_6 = Total forb production

a.	at least 175 pounds per acre	1.0
b.	125 < forbs < 175 pounds per acre	0.8
c.	75 < forbs ≤ 125 pounds per acre	0.6
d.	25 < forbs ≤ 75 pounds per acre	0.4
e.	20 < forbs ≤ 25 pounds per acre	0.2
f.	0 < forbs ≤ 20	0.1
e.	zero forb production	0

1/ Annual production for all forb species was totaled in pounds per acre, averaged for all plots in each vegetation type, and then scaled to SI values as above.

Table 2:

Characteristics of Talkeetna and Beluga Subbasin Vegetation Types as Described by Habitat Parameters for Moose Range

SCS Vegetation Type	Habitat Parameters V_1 Browse Species (percent total)	V_2 Production lbs/acre	V_3 Canopy Type Cover Class	V_4 VAVI Cover Class
21	Al(100)	548	cl CF	c
22	Al(92)Sa(8)	696	cl DF	a
24	Al(77)Sa(13) BP(10)	320	cl MF	a
25	Sa(100)	188	cl CF	a
26	Al(94)BP(4) Sa(2)	403	cl MF	b
27	Al(71)Sa(29)	473	cl DF	c
28	Al(100)	127**	cl DF	c
29	Al(100)	247	cl MF	c
31	Sa/Bn*	393	op CF	a
32	Sa/(100)	456	op MF	c
33	Al(72)Sa(28)	924	op MF	c
34	Sa(58)Al(42)	377	op MF	c
35	Al(100)	31	op DF	c
36	Al(100)	552	op MF	c
41	Al(100)	40	cl CF	a
42	BP(100)	48	cl CF	a
43	Al(100)	40	op CF	b
60	Al(100)	1,082	TS	c
61	Sa(82)Al(18)	2,628	TS	c

Classifications are based on SCS/FS vegetation data for the Talkeetna subbasin.

* not measured in plot of pure type, but mentioned as being heavily browsed in area, present in heterogeneous plot.

** based on heterogeneous type, one plot.

Abbreviations:

VAVI = *Vaccinium vitis-idaea*
Al = *Alnus* spp.
Sa = *Salix* spp.
BP = *Betula papyrifera*
BN = *Betula nana*
CF = coniferous forest
DF = deciduous forest
MF = mixed coniferous-deciduous forest
TS = tall shrub
cl = closed
op = open

Table 3:

Suitability Index (SI) Values for Moose Winter Range Habitat Parameters by Vegetation Type

SCS Vegetation Type	Habitat Parameters V_1	V_2	V_3	V_4	Winter Range
21	0.2	0.8	0.8	0	.5
22	0.3	1.0	0.8	0.06	.7
24	0.7	0.8	1.0	0.06	.9
25	0.9	0.6	1.0	0.06	.9
26	0.3	0.8	1.0	0.03	.6
27	0.7	0.8	0.8	0	.8
28	0.2	0.6	0.8	0	.5
29	0.2	0.6	1.0	0	.5
31	0.7	0.8	0.6	0.06	.8
32	0.9	0.8	0.4	0	.8
33	0.7	1.0	0.4	0	.7
34	0.7	0.8	0.6	0	.7
35	0.2	0.2	0.6	0	.3
36	0.2	0.8	0.6	0	.5
41	0.2	0.2	0.8	0.06	.4
42	0.8	0.2	0.8	0.06	.7
43	0.2	0.2	0.6	0.03	.3
60	0.2	1.0	0.4	0	.5
61	0.9	1.0	0.4	0	.8

See Table 2 for definitions and vegetation characteristics on which these SI values are based. Classifications are based on SCS/FS vegetation data for the Talkeetna Subbasin.

Table 4:

Characteristics of Talkeetna and Beluga Subbasin Vegetation Types as Described by Habitat Parameters for Moose Spring/Summer/Fall (S/S/F) Range

SCS Vegetation Type	Habitat Parameters V_1 Browse Species (percent total)	V_2 Production lbs/acre	V_5 S/S/F Cover	V_6 Forbs lbs/acre
21	Al(100)	428	cl CF	291
22	Al(94)Sa(4) Be(2)	636	cl DF	106
24	Al(60)Sa(23) Bp(16)	205	cl MF	71
25	Sa(54)BN(46)	47	cl CF	143
26	Al(83)BP(14) Sa(3)	147	cl MF	68
27	Al(50)Sa(50)	310	cl DF	22
28	Al(86)Sa(14)	598	cl DF	40
29	Al(100)	247	cl MF	96
31	BN(100)	360	op CF	64
32	Sa(100)	313	op MF	214
33	Al(70)BN(27) Sa(3)	105	op CF	370
34	Al(99)BN(1)	122	op MF	121
35	Al(100)	56	op DF	132
36	Al(100)	237	op MF	18
41	Al(100)BN(4)	19	cl CF	
42	0	0	cl CF	14
43	Al(100)	23	op CF	19
50	0	0	TG	0
51	0	0	LS	0
52	0	0	HSG	0
60	Al(100)	649	TS	38
61	Sa(79)Al(21)	560	TS	234
62	Sa(74)BN(26)	323	LS	121
63	BP(100)	3	TG	381
64	0	0	SGT	21
65	BN(57)Sa(43)	134	HT	14
66	BN(65)Al(31)Sa(4)	103	ST	38
67	0	0	MCT	13
68	0	0	HSG	0
69	BN(90)Sa(5) Al(5)	111	LS	12

Abbreviations:

cl = closed
op = open
TS = tall shrub
TG = tall grass
LS = low shrub
DF = deciduous forest
CF = coniferous forest
MF = mixed coniferous deciduous forest
ST = shrub tundra

VAVI = Vaccinium Vitis-idaea
Al = Alnus spp.
Sa = Salix spp.
BP = Betula papyrifera
BN = Betula nana
SGT = sedge-grass tundra
HSG = herbaceous sedge-grass
MCT = mat and cushion tundra

Table 5:
Suitability Index (SI) Values for Moose Spring/Summer/Fall (S/S/F) Range Habitat Parameters by Vegetation Type

SCS Vegetation Type	Habitat Parameters V_1	V_2	V_5	V_6	Spring/ Summer/Fall Range
21	0.2	0.8	1.0	1.0	0.6
22	0.3	1.0	1.0	0.6	0.6
24	0.9	0.6	1.0	0.4	0.8
25	0.7	0.2	1.0	0.8	0.7
26	0.5	0.6	1.0	0.4	0.6
27	0.7	0.8	1.0	0.2	0.7
28	0.5	1.0	1.0	0.4*	0.7
29	0.2	0.6	1.0	0.6	0.5
31	0.6	0.8	1.0	0.4	0.7
32	0.9	0.8	1.0	1.0	0.9
33	0.5	0.6	1.0	1.0	0.7
34	0.2	0.6	1.0	0.6	0.5
35	0.2	0.4	1.0	0.8	0.5
36	0.2	0.6	1.0	0.1	0.4
41	0.2	0.1	1.0	0.1	0.3
42	0	0	1.0	0.1	0.2
43	0.2	0.1	1.0	0.1	0.3
50	0	0	0	0	0
51	0	0	0	0	0
52	0	0	0	0	0
60	0.2	1.0	1.0	0.2	0.5
61	0.8	1.0	1.0	1.0	0.9
62	0.8	0.8	0	0.6	0.6
63	0.8	0.1	0	1.0	0.5
64	0	0	0	0.2	0.1
65	0.8	0.6	0	0.4	0.5
66	0.6	0.6	0	0.4	0.4
67	0	0	0	0.1	0.1
68	0	0	0	0	0
69	0.6	0.6	0	0.4	0.4

*Estimated from one plot in heterogeneous type

See Table 4 for definitions and vegetation characteristics on which these SI values are based. Classifications are based on SCS/FS vegetation data for the Talkeetna Subbasin.

Non-forest and non-tall shrub types greater than 440 yards from cover are not S/S/F range.

MOOSE (1:63,360 and 1:250,000)

Map Subbasin into 11 categories of moose habitat suitability as follows:

Category	Criteria for Mapping by SCS Vegetation Code	Value to Moose
1	24, 25, 27, 61	high WR, mod/high S/S/FR
2	22, 26, 31, 32, 33	mod/high WR, high or mod/high S/S/FR
3	21, 28, 29, 34, 36, 60	mod/high or mod WR and S/S/FR
4	41, 42	mod/high or mod WR and low S/S/FR
5	35, 43	low WR and low or mod S/S/FR
6	62, 63, 65 if within 440 yards of cover 1/	mod/high S/S/FR, not WR
7	66, 69, if within 440 yards of cover	mod S/S/FR, not WR
8	64, 67, if within 440 yards of cover	low S/S/FR, not WR
9	50, 51, 52, 68	vegetated types of insignificant value as either moose WR or S/S/FR
10	70 through 83	none, are disturbed or barren of vegetation
11	91 through 97	water bodies

Abbreviations:
WR = winter range
S/S/FR = spring/summer/fall range
mod = moderate

1/ "Cover" for S/S/FR is provided by all forests and tall shrublands, vegetation types 21, 22, 24, 25, 26, 27, 28, 29, 31, 32, 33, 34, 36, 41, 42, 43, 60, and 61. I have assumed that grid cells are 10 acres and this search will be defined by a distance of two grid cells from the cell of interest.

Appendix D:

Examples of field procedures and data forms used during the Susitna River Basin vegetation inventory

HABITAT INVENTORY PLOT

At each point of the location, estimate and record habitat data on the 1' X 2' north half of the frame. Record the following data on the Habitat Plot Sheet:

SPECIES NAME — ITEM 82

Record species name as listed. Record unknowns by number, bring sample back to camp to be keyed and identified. Try to collect some blossoms or seeds since these aid the identification process.

SPECIES CODE — ITEM 83

Record species by code as listed on the back of the form. If not listed refer to SCS national list of scientific plant names for the proper code. This item can be done in the camp or office.

HEIGHT — ITEM 84

Estimate and record the average height of each species at each point. Use the following height classes and codes.

Code	Height Class
1	0-6 inches
2	6-18 inches
3	18 inches - 3 feet
4	3-10 feet
5	over 10 feet

ITEM 85 CANOPY COVER

At each point, estimate and record canopy cover by species using the following codes:

Code	Class
1	1- 5%
2	5-20%
3	20-40%
4	40-60%
5	60-80%
6	80-95%
7	95-100%

Canopy cover is not merely a measure of area covered by leafy portions of the plant. Rather, it can be thought of as amount of ground area influenced by a plant within the plot. It is estimated by visualizing the plant as a ploygon with sides drawn about extremities of the canopy. See diagram. Most communities are composed of several layers of different plant species. Therefore, when canopy cover is added for all species in the plot, ground cover can actually be greater than 100 percent.

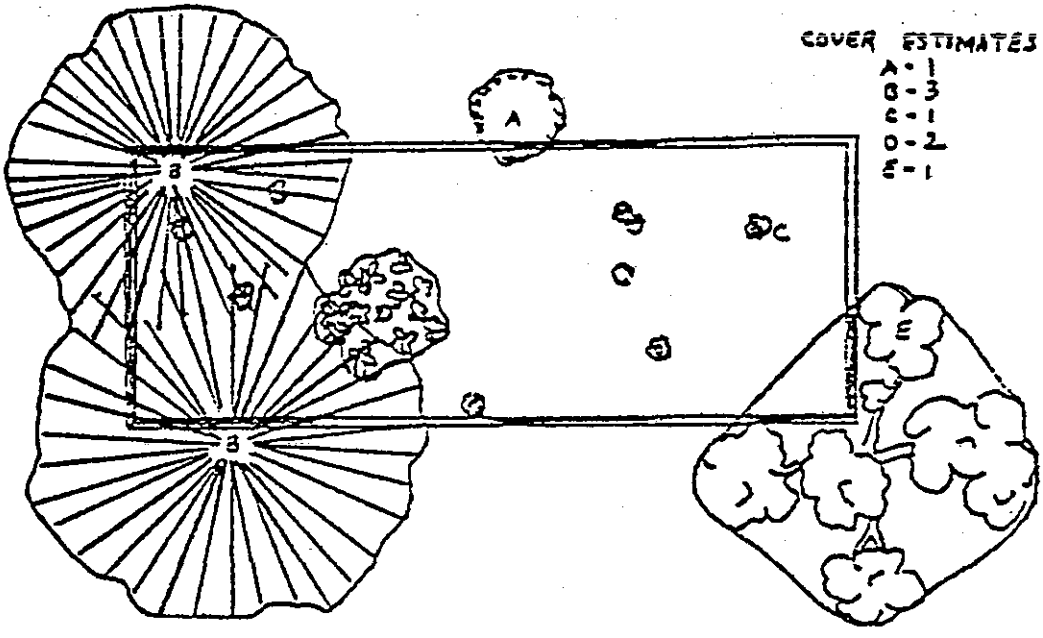

Figure 2. Diagram illustrating method of estimating canopy coverage. The biologic soundness of using the vertical projection of a polygon drawn about the extremities of the plant canopy is illustrated by E, which, by accident of foliage arrangement, actually has no leaves directly above the plot frame. A plant of this type probably exerts at least as much influence on the ecosystem outlined as does A.

DENSITY OF STEMS — ITEM 86

Count and record the number of woody stems inside the plot frame that extend above 6 inches in height.

HEDGING (PAST USE) — ITEM 87

Hedging results from past use of plants by animals for feed or browse. Past use is defined as one year old, usually several stems of new growth are appearing where each single stem was browsed. Estimate this past use and record with the following codes:

Code	Class
1	None
2	Light use
3	Moderate use (40-60%)
4	Heavy use (clubbiness)

BROWSE (CURRENT USE) — ITEM 88

Estimate present use of the species for animal browse and record using the following codes:

Code	Class
1	None
2	Light
3	Moderate (40-60%)
4	Heavy use (clubbiness)

WILDLIFE SIGNS — ITEMS 89-96

During the process of measuring the understory vegetation, keep a mental tally of wildlife use signs in the area. Estimate and record using the items listed below. Additional comments covering items not coded (such as scat, hair, feathers, etc.) may be made on the back of the Habitat Plot Sheet.

TRAILS-TYPE — ITEM 89

Code	Type
01	No trails
02	Rodent
03	Small game
04	Large game

HABITAT PLOT SHEET

4 LOCATION	1	2	3	4	61 PLOT SIZE	5	6	7
						0	0	2.

	ITEMS	84	85	86	86	87	88
82 SPECIES NAME	83 SPECIES CODE (8 9 10 11 12 13)	HEIGHT	CANOPY	DENSITY	#STEMS	HEDGE	BROWSE
	POINT 1	14	15	16	17	18	19
	POINT 2	20	21	22	23	24	25
	POINT 3	26	27	28	29	30	31
	POINT 4	32	33	34	35	36	37
	POINT 5	38	39	40	41	42	43
	POINT 6	44	45	46	47	48	49
	POINT 7	50	51	52	53	54	55
	POINT 8	56	57	58	59	60	61
	POINT 9	62	63	64	65	66	67
	POINT 10	68	69	70	71	72	73

ITEM 90 TRAILS-NUMBER

Code	Item
01	No trails in area
02	Several (3-5) trails through area
03	Area heavily bisected by trails

ITEM 91 NESTING TREES/PHAIRY TREES

Code	Item
01	None observed
02	One or more bird nests
03	One or more squirrel trees
04	One or more cavity trees

ITEM 92 HUMMOCKS

Hummocks are small mounds often found on wet sites. They are usually topped by grasslike plants of the genus carex. and provide shelter to small wildlife.

Code	Item
1	None present
2	Less than 50% of area covered
3	Over 50% of area covered

ITEM 93 HUMMOCK SIZE CLASS

Record average size class of the hummocks observed.

Code	Item
1	6 inches high
2	6-12 inches high
3	12-20 inches high
4	20 inches high

ITEM 94 CAVES, BURROWS

Code	Item
01	None observed
02	One or more burrows noted
03	One or more caves noted

ITEM 84 HEIGHT

ode	Height Class
1	0-6 inches
2	6-18 inches
3	18 inches - 3 feet
4	3-10 feet
5	over 10 feet

ITEM 85

Code	Class
1	1- 5%
2	5-20%
3	20-40%
4	40-60%
5	60-80%
6	80-95%
7	95-100%

ITEM 87 HEDGING (PAST USE)

Code	Class
1	None
2	Light use
3	Moderate use (40-60%)
4	Heavy use (clubbiness)

ITEM 88 BROWSE (CURRENT USE)

Code	Class
1	None
2	Light
3	Moderate (40-60%)
4	Heavy use (clubbiness)

WILDLIFE APPRAISAL FORM

4. LOCATION (1 2 3 4)

POINT NUMBER	TRAILS			NEST TREES		TREE CAVITIES		HUMMOCKS	HUMM. SIZE	NO. OF CAVES	NO. OF BURROWS	CONE PROD.	OPTIONAL												REMARKS
	NO. OF RODENT	NO. OF SM GAME	NO. OF BIG GAME	NO. OF BIRD	NO. OF SQUIRREL	NO. <5 INCH DIA	NO. ≥5 INCH DIA.																		
40	90A	90B	90C	91A	91B	95A	95B	92	93	94A	94B	96													
5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21	22	23 24	25 26	27	28	29 30	31	32	33	34 35	36	37	38	39	40	41 42	
01																									
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TL																									TOTALS
5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21	22	23 24	25 26	27	28	29 30	31	32	33	34 35	36	37	38	39	40	41 42	

ITEM 92 HUMMOCKS

Code	Item
1	None present
2	Less than 50% of area covered
3	Over 50% of area covered

ITEM 93 HUMMOCK SIZE CLASS

Code	Item
1	6 inches high
2	6-12 inches high
3	12-20 inches high
4	20 inches high

ITEM 96 CONE PRODUCTION

Code

1 - MANY CONES ON 75-100% OF TREES; SOME CONES ON ALL TREES
2 - MANY CONES ON 50-75% OF TREES; SOME CONES ON ALL TREES
3 - FEW CONES ON 50-75% OF TREES; MANY CONES ON SOME TREES
4 - FEW CONES ON 75-95% OF TREES; MANY CONES ON OCCASIONAL TREES
5 - FEW CONES ON OCCASIONAL TREES; OR NO CONES ON ANY TREES

TREE CAVITIES ≥5" ITEM 95A

Keep a line tally of the number of tree cavities less than 5 inches diameter and greater than 2 inches deep. After all 10 points have been visited record the total number observed.

TREE CAVITIES ≥5" ITEM 95B

Keep a tally as above and record the total number of tree cavities greater than 5 inches in diameter after all points have been visited.

CONE PRODUCTION ITEM 96

Observe and record cone production by the following codes:

1 75% of the trees have a lot of cones
2 50-75% of the trees have a lot of cones
3 50% of the trees have a lot of cones
4
5

RANGE PLOT

Read and record on the Range Form the estimated weight in grams of current year's growth by species that lie within the perimeter of the 4 sq. foot (2x2)plot. Data will not be collected on the following trees or woody shrubs over 4 1/2 feet in the 4 sq. ft. plot:

Aspen	Alder
Paper Birch	Elderberry
Cottonwood	Willow
Shurb Birch	Spruce
Mtn. Ash	

When estimating the weights or collecting the current year's growth, consider only the portion of the plant inside the vegetation frame. Measure portions of plants which fall inside the vertical projection of frame even if the plant is rooted outside. Likewise, ignore all parts of plant outside the vertical projection of the metal frame even though the plant may be rooted inside.

Clip the current years growth after estimating weights by species on the range plot. Clip the first plants of each species encountered within plots 1 through 5, and the first plants of each species encountered within plots 6 through 10.

Place the current year's growth by species in separate paper bags and using water proof felt tip pen, label with:

1. location number
2. point number
3. date (month, day, year)
4. species
5. estimator's name

After all the plants have been clipped, put in paper bags and labeled, place all bags in a plastic bag. Return the specimens to camp for weighing.

Record the actual weight on the range form and on the paper bag.

ITEM 97 MAPPING UNIT

Identify and record the mapping unit at each point. This is necessary in order to identify points located in vegetative intrusions that were not typed out on the photo. Use the following codes:

I CLOSED FOREST

Code	Mapping Unit
021	Closed Forest - White spruce - short - less than 30' tall.
025	Closed Forest - White spruce - tall - greater than 30' tall.
041	Closed Forest - Black spruce - short - less than 30' tall.
042	Closed Forest - Black spruce - tall - greater than 30' tall.
045	Closed Forest - Mt. Hemlock - short - less - than 30' tall.
046	Closed Forest - Mt. Hemlock - tall - greater than 30' tall.
022	Closed Forest - Deciduous/Mixed - young - less than 40 years old.
024	Closed Forest - Deciduous/Mixed - medium age - 40 - 100 years old.
026	Closed Forest - Deciduous/Mixed - old age - greater than 100 years old.
027	Closed Forest - Cottonwood - young - less than 40 years old.
028	Closed Forest - Cottonwood - medium age - 40 - 100 years old.
029	Closed Forest - Cottonwood - old age - greater than 100 years old.

II OPEN FOREST

031	Open Forest - White spruce - short - less than 30' tall.
033	Open Forest - White spruce - tall - greater than 30' tall.
043	Open Forest - Black spruce - short - less than 30' tall.
032	Open Forest - Deciduous/Mixed - medium age - 40 - 100 years old.
034	Open Forest - Deciduous/Mixed - old age - greater than 100 years old.
035	Open Forest - Cottonwood - medium age - 40 - 100 years old.
036	Open Forest - Cottonwood - old age - greater than 100 years old.

III NON-FOREST

050	Non-forest - saltwater wetland - grassland.
051	Non-forest - saltwater wetland - low shrub.
052	Non-forest - saltwater wetland - tidal marsh.
060	Non-forest - tall shrub - alder.
061	Non-forest - tall shrub - alder - willow
062	Non-forest - low shrub - willow - resin birch.
063	Non-forest - grassland.
064	Non-forest - tundra - sedge - grass.
065	Non-forest - tundra - herbacious.
066	Non-forest - tundra - shrub.
067	Non-forest - tundra - mat and cushion.
068	Non-forest - wetland - sphagnum bog.
069	Non-forest - wetland - sphagnum - shrub bog.

IV CULTURAL

070	Cultural Influence.

V BARREN

080	Barren - mud flats.
081	Barren - rock.
082	Barren - bare ground.

VI SNOW

085	Permanent snow and ice - snow field.
086	Permanent snow and ice - glacier.

VII WATER

091	Water - lakes - less than 40 ac.
092	Water - lakes - less than 10 ac. greater than 40 ac.
096	Water - streams and rivers - less than 165 ft. greater than 660 ft. wide.
097	Water - rivers - less than 1/8 mile wide (660 ft.)

V RANGE PRODUCTION FORM

4 LOCATION | | | | 61 PLOT SIZE 0 1 0 4

97 MAP UNIT

82 SPECIES

98 ESTIMATED WEIGHT PER SPECIES

WEIGHT OF CLIPPED PLANTS.

SPECIES CODE	POINT 1	POINT 2	POINT 3	POINT 4	POINT 5	POINT 6	POINT 7	POINT 8	POINT 9	POINT 10	FIRST CLIPPING: 99 POINT NO.	100 WET WEIGHT	101 DRY WEIGHT	SECOND CLIPPING: 102 POINT NO.	103 WET WEIGHT	104 DRY WEIGHT
8 9 10 11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30 31	32 33 34	35 36 37	38 39 40	41 42 43	44 45	46 47 48	49 50 51	52 53	54 55 56	57 58 59

ITEM 82 SPECIES

Enter the common or scientific name for each plant encountered on the plot.

ITEM 83 SPECIES CODE

Enter the species code for the plant as found on the back of the habitat form.

ITEM 98 ESTIMATED WEIGHT PER SPECIES

Estimate and record by species the weight of all plants (or parts of plants) which fall within the sampling frame. Enter the weight using three digits. Example:

Weight	Code
3 grams	003
23 grams	023
321 grams	321
no plant present	001
trace	888

Record code 001 if one of the observed species is not found in the 2x2 plot.

Record code 888 when there is only a trace of a particular species. A trace would weigh 2 grams or less.

ITEMS 99,102 CLIPPED POINT NUMBER

The first plants of each species encountered within plots 1-5 and within plots 6-10 will be clipped and weighed. Record the appropriate point numbers on which each species is clipped and weighed.

Code	Point	Code	Point
01	1	06	6
02	2	07	7
03	3	08	8
04	4	09	9
05	5	10	10

ITEMS 100, 103 WET WEIGHT

Record the wet weight of the current year's growth for each species clipped. Record the weight in grams as a 3-digit code. This may be done on location or later the same day at camp. Record 001 if no plants were clipped. Record 888 if there are 2 grams or less of any species.

WET WEIGHT (CONT.) ITEMS 100,103

Weight	Code
3 grams	003
313 grams	313
No weight specimen	001
Trace under 2 grams	888

DRY WEIGHT ITEMS 101,104

NOT FIELD RECORDED. Recorded after vegetation has been dried. The weight recorded will be for the same material weighed in items 100 and 103. Use the same codes for traces and missing data.

TALL BRUSH PLOT

On points 4 and 8 of the location, establish the 10'x 10' tall brush plot as shown on the vegetation location diagram.

The plot should be viewed three-dimensionally (length, width, and height) and only the vegetation within that cube evaluated regardless of its origin. For example, if a plant is rooted on the plot, only that portion within the plot boundary should be considered even though a portion of the plant extends beyond the plot boundary. If the plant is rooted out of the plot boundary, but extends onto the plot, only that portion which lies within the perimeter of the plot should be considered.

The common tall brush species are already labeled on the form. Enter the common name and species code of any additional tall brush species found on the plot.

MAXIMUM DIAMETER ITEM 105

The maximum diameter (mm) of stem considered in estimating available browse is indicated here. Indicated in this column for each species is the maximum diameter of twigs estimated and clipped as available browse. If species is not listed use 5 millimeters unless other instructions are given.

NUMBER OF UNITS ITEM 106

For each species select a sample unit (2 or 3 branches) within the plot perimeter. Using this sample unit, estimate the number of units of this size that remain inside the plot boundary and under 10 feet in height. Record the number of units. (Be sure to include the sample unit).

WET WEIGHT ITEM 107

Clip all the current year growth from the selected sample unit for each species and place it in a paper bag. Label the bag with:

1. location number
2. point number
3. date (month/day/year
4. species
5. plot size
6. number of units

Use a waterproof felt tip marker to label the bag. Place in plastic bag and bring the sample back to camp. Green/or wet weights may be determined in the field or at camp.

Deduct the weight of the bag to obtain the true weight of the green current years growth.

Record the weight on the bag and on the form. Even if green weight is determined in the field, the sample must be brought back to camp to obtain dry weights.

DRY WEIGHT ITEM 108

NOT FIELD RECORDED. This process will be carried out in the office at a later date after the green material has dried. Record the dry weight on the form and on the paper bag.

NUMBER OF UNITS ITEM 109

Using the same sample unit selected for the measure of productivity under 10 feet in height, estimate the number of like size sample units that protrude above an imaginary 10 foot line and still within the plot boundary (10'x10' square) projected straight up in the area. Enter the number of estimated sample units on the form.

TALL BRUSH FORM

4 LOCATION 1 2 3 4 — 6 PLOT SIZE 5 6 7

82 SPECIES NAME	125 MAXIMUM DIAMETER	83 SPECIES CODE	POINT 4: PRODUCTIVITY <10': 106 NO. OF UNITS	107 WET WEIGHT	108 DRY WEIGHT	PRODUCTIVITY >10': 109 NO. OF UNITS	AVAILABLE BROWSE: 110 NO. OF STEMS	111 % BRWSD TWIGS	112 WET WEIGHT	113 DRY WEIGHT	POINT 8: PRODUCTIVITY <10': 106 NO. OF UNITS	107 WET WEIGHT	108 DRY WEIGHT	PRODUCTIVITY >10': 109 NO. OF UNITS	AVAILABLE BROWSE: 110 NO. OF STEMS	111 % BRWSD TWIGS	112 WET WEIGHT	113 DRY WEIGHT
		8 9 10 11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48	49 50 51	52 53	54 55 56	57 58 59
ASPEN																		
PAPER BIRCH																		
COTTONWOOD																		
ALDER																		
ELDERBERRY																		
WILLOW																		
ADD AS NEEDED																		
		8 9 10 11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48	49 50 51	52 53	54 55 56	57 58 59

ITEM 110 AVAILABLE BROWSE

In a sample unit, count the number of stem tips that have a diameter less than the maximum diameter indicated in Item 105 and that lie within the perimeter of the tall brush plot (100 sq. ft.) below a height of 10 feet. Include all stems which are less than the maximum diameter whether current year's growth or not. Multiply by the number of units and record.

ITEM 111 PERCENT BROWSED TWIGS

Estimate and record the percentage of twigs showing recent use as browse.

ITEM 112 WET WEIGHT, BROWSE

At the maximum diameter indicated in Item 105 or at 5.0 millimeters, clip and weigh 10 stem tips and enter the average weight. Place the stems in a paper bag and label the bag with:

1. location number
2. point number
3. date (month, day, year)
4. plot size
5. total weight of sample
6. average weight of stem
7. number of stems in the plot

Write with a waterproof felt tip marker. Place in a plastic bag and bring back to camp for further analysis.

ITEM 113 DRY WEIGHT, BROWSE

NOT FIELD RECORDED. This process will be carried out in the office at a later date. Weigh the sample after the green material dries and obtain average dry weight per stem. Enter the data on the form. Record the dry weight on the paper bag.

114. Slope (degrees)

A direct measurement of the average slope of the plotless area visible from each transect using a clinometer along the direction of the slope.

115. Aspect (degrees from true north)

The aspect of the slope along which each transect runs should be measured using a magnetic compass. If the transect is through an area characterized as flat, ridgetop, narrow valley bottom, water, indicate as such and do not record aspect.

116. Micro-relief

A - Elevated micro-relief of tussocks, hummocks, polygons, and ridges extensive
B - Elevated features present with areas of relatively flat micro-relief
C - Uniformly flat or nearly so

A subjective evaluation of the micro-relief within each plot.

117. Micro-topography

A - Ground flat
B - Small hummocks up to 6 inches tall
C - Tall hummocks 6 to 12 inches tall
D - Undercut and collapsing hummocks 12 to 20 inches tall
E - Areas with hummocks greater than 12 inches tall

118. Type of vegetation in ground cover

A - Herbaceous plants which tend to form tussocks and hummocks, mostly less than 2 feet tall
B - Low shrubs which tend to form clumps and hummocks such as dwarf birch or bog myrtle
C - Combination of both A and B
D - Either A, B, or C, but with extensive undecomposed moss cover
E - Other plant types
F - Other plant types with extensive undecomposed moss cover or only moss

An ocular estimate of the dominant vegetation type within each plot.

119. White spruce cone production

A - Greater than 500 cones on 75-100% of trees; 100-500 cones on all trees
B - Greater then 500 cones on 50-75% of trees; 100-500 cones on all trees
C - Less than 100 cones on 50-75% of trees; Greater than 500 cones on some trees
D - Less than 100 cones on 50-75% of trees; Greater than 500 cones on occasional trees
E - Less than 100 cones on occasional trees; or no cones on any trees

It is difficult to estimate the number of cones per tree. Standardization of the estimates of the various biologists involved in the study is necessary through a process of estimating and then counting many trees. Once estimates are reliable, white spruce trees selected by point centered quarter method should be evaluated. Additional trees may have to be randomly selected for evaluation.

120. Small tree cavities (less than 5" diameter and greater than 2" deep)

Record the number.

121. Large tree cavities (greater than 5" diameter)

122. Average size of openings among tree trunks (feet)

A - Openings 21-30 feet across
B - Openings 31-40 feet across
C - Openings 15-20 feet across
D - Openings less than 15 or greater than 40 feet across

An ocular estimate of the average diameter of openings between trunks of trees as they occur in the plotless area visible from each transect.

123 . Maximum height of ground vegetation (inches)

An ocular estimate of the maximum height of understory vegetation in the openings among the trees. Measure maximum height within each plot that fall within an opening and estimate maximum height in the openings within the plotless area visible form each transect. Round to the nearest foot.

124 . Average height of ground vegetation in openings at least 15 feet wide (B

An ocular estimate of the maximum height of understory vegetation within plots or plotless areas visible from each transect which are located in openings greater than 15 feet side among tree trunks.

125 . Percent bryophyte and graminiform cover less than one foot high in openings

An ocular estimate of the percent bryophyte and graminiform cover less than one foot in height and within openings between shrub clumps and/or trees. Estimates may be made within plots or within the plotless area visible from each transect, whichever method is most appropriate.

126 . Edaphic mixture within stand

A - Varied moisture conditions; numerous openings and marshy areas with herbs
B - Varied moisture conditions but with marshy areas less dominant
C - Uniformly dry
D - Uniformly moist
E - Almost continually flooded
F - Continually flooded

WILDLIFE FORM

LOCATION			
62	5	6	7
PLOT SIZE	0	0	4

NOTES:

ITEMS / Parameters	POINT 1	POINT 2	POINT 3	POINT 4	POINT 5	POINT 6	POINT 7	POINT 8	POINT 9	POINT 10
114 Slope (Degrees)										
115 Aspect (Degrees from true north)										
116 Micro-relief										
117 Micro-topography										
118 Type of vegetation in ground cover										
119 White spruce cone-production										
120 Small tree cavities										
121 Large tree cavities										
122 Av. size of openings among tree trunks										
123 Max height of ground vegetation (in)										
124 Av hgt. ground veg in openings > 15'										
125 %Bryophyte/gramininform < 1' in openings										
126 Edaphic mixture within stand										
127 Interspersion of shrubs & lower veg.										
128 Interspersion w/moose cover habitat										
129 Interspersion with wetlands										
130 Bank suitability										
131 % cover of aquatic forage										
132 Dominant aquatic vegetation										
133 Type of lentic water body										
134 Degree of eutrophication										
135 Water depth										
136 Rise or fall from norm H_2O depth										
137 Substrate type										
	8 9 10	11 12 13	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29 30 31	32 33 34	35 36 37

127. Interspersion of shrubs and lower vegetation

A - Shrubs 3-8 feet tall, isolated in extensive areas of vegetation less than one foot
B - Shrubs 3-8 feet tall in clusters scattered variously throughout areas of vegetation less than 1 foot
C - Shrubs 3-8 feet tall in wide belts dominating area with occasional openings of vegetation less than 1 foot

A subjective evaluation of the interspersion of shrubs and lower vegetation may be based on the plotless area visible from each transect.

128. Interspersion with moose cover habitat (forests, shrublands)

A - Highly interspersed with pockets of cover habitat
B - Moderately interspersed - pockets of cover habitat common but not abundant
C - Few or no significant pockets of cover habitat, but homogeneous cover type is bordered by forests or shrublands
D - Few or no significant pockets of cover habitat; bordered by a small amount of forest or shrubland vegetation
E - No significant cover habitat within any reasonable distance

A subjective evaluation of the interspersion of clumps of trees and/or shrubs within and around the homogenous vegetation type being samples based on the plotless area visible from each transect.

129. Interspersion with wetlands (marsh, shallow lentic, or slow lotic water)

A - Highly interspersed with wetland pockets; numerous bogs, marshes, ponds, shallow lakes or sloughs
B - Moderately interspersed - wetland pockets common but not abundant
C - Few or no significant wetland pockets, but homogenous cover type is bordered by areas of wetland habitat
D - Few or no significant wetland pockets; bordered by a small amount of wetlands
E - No significant wetland habitat within any reasonable distance

A subjective evaluation of the interspersion of wetlands and/or shallow freshwater areas within and around the homogeneous vegetation type being sampled based on the plotless area visible from each transect.

130. Bank suitability

A - Most of bank (at least 75%) well vegetated with perennial plants; not slumping or eroded
B - Most of bank (at least 75%) well vegetated with annual plants; not slumping or eroded
C - More than 25% of bank raw, bare, and undercut
D - Bank steep and high; slumping, subject to erosion
E - Bank of solid rock; steep

131. Percent cover of aquatic forage

An ocular estimate of the percent cover of herbaceous aquatic plan such as eelgrass, duckweeds, pondweeds, water lilies, cat-tails an horse-tails. The most appropriate sampling method should be used.

132. Dominant aquatic vegetation

A - Emergent vegetation (streams, ponds, lakes)
B - Floating and submerged vegetation (streams, ponds, lakes)

An ocular estimate based on the relative percent covers of emergent vegetation versus floating and submergent vegetation in a freshwater body. List plant species in notes.

133. Type of lentic water body

A - Relatively clear shallow water; open shoreline (not closed in by trees) with extensive emergent vegetation
B - Relatively clear, shallow water; some emergent vegetation; with/without close trees
C - Deep water with low spongy floating mat
D - Deep oligotrophic water; no aquatic vegetation
E - Stagnant water with plankton blooms

An ocular estimate of the depth and vegetation pattern of a lentic water body and the tree situation along the shoreline. "Shallow" is defined as not so deep as to preclude considerable digging and (ing by trumpeter swans for lower aquatic plant parts, roots, tubers, et

134. Degree of eutrophication (May to October)

A - Highly oligotrophic
B - Slightly oligotrophic
C - Moderately oligotrophic
D - Distinctly eutrophic
E - Highly eutrophic

"Highly oligotrophic" refers to freshwater bodies that are poor in nutrients and therefore have few or no aquatic insects or plants and are likely to be very deep. "Slightly eutrophic" refers to freshwater bodies in which plankton and aquatic plants and insects are present, but not abundant. "Moderately eutrophic" refers to freshwater bod(that have moderate amounts of plankton and aquatic plants and insects, a moderate accumulation of organic material in the littoral zone, but at least 70 percent open water. "Distinctly eutrophic" refers to freshwater bodies that have abundant plankton and aquatic insects and plants, extensive organic material in the littoral zone, and only 40 to 70 percent open water. "Highly eutrophic" refers to freshwater bodies that are either shallow and choked with plant growth with less than 40 percent open water or, if plants are absent, too low in oxygen to support aquatic insects. A subjective evaluation based on general reconnaissance of random representatives of each type of freshwater

135. Water depth (inches)

The depth of a shallow freshwater body may be determined with a weighted measure tape along the most appropriate transects. Depths less than 30 inches are ideal for moose. Depths greater than 80 inches are too deep for moose and need not be measured.

136. Rise or fall from normal water depth (feet)

A subjective evaluation of the seasonal fluctuations of the water level of a freshwater body may be made based on the shoreline characteristics. Fluctuations of less than two feet need not be quantified as they present no problem to beavers.

137. Substrate type

A - Lake on shale slide on steep slope
B - Lake on other substrate
C - Stream channel protected from rapid downcutting; channel bed lined with large boulders, dikes, moraines, and slides not of recent origin; rocks stable (glacial till, schist, granite)
D - Stream channel bed lined with loose soft fine-textures materials readily movable in water; may be currently eroding or filling; rocks unstable types such as shale and sandstone

Investigate available geological information for the local area. Field reconnaissance along representative types of lotic water bodies should allow adequate subjective evaluation.