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FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF ELECTRIC POWER REGULATION

DRAFT ENVIRONMENTAL IMPACT STATEMENT

SUSITNA HYDROELECTRIC PROJECT
FERC NO. 7114 - ALASKA

Volume 5.

Appendix J. Terrestrial Botanical Resources

Appendix K. Terrestrial Wildlife Resources

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SUSITNA HYDROELECTRIC PROJECT, FERC NO. 7114

APPENDIX J

TERRESTRIAL BOTANICAL RESOURCES

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APPENDIX J. TERRESTRIAL BOTANICAL RESOURCES

J.1 AFFECTED ENVIRONMENT

J.1.1 Introduction

The sites of the proposed Susitna project and most of the project alternatives considered in this document are located in Southcentral Alaska, almost entirely within an ecoregion classified by Bailey (1978) as the Alaska Range Province of the Subarctic Division. The climate of this region is similar to that of Interior Alaska and is characterized by long, severe winters and hot, dry summers. Annual precipitation averages 16 inches (in) [410 millimeters (mm)], and temperatures range from 90°F (32°C) to -70°F (-57°C). Permafrost is often discontinuous and can be absent from large areas on south-facing slopes and along river floodplains. Permafrost and soil types are discussed in Section E.1 of Appendix E.* Major vegetation types include conifer, deciduous, and mixed conifer-deciduous forests (and their various successional stages) at lower elevations, and shrublands and tundra systems at higher elevations above the timber line [about 2,500 to 3,500 feet (ft), or 760 to 1,100 meters (m) MSL] (Bailey, 1978).

The general distribution of major vegetation classes within Southcentral Alaska in relation to the sites of the proposed dams and alternative power generation facilities is illustrated in Figure J-1. Each of the vegetation classes delineated in the figure is described briefly in Table J-1. The classification system presented in the table is useful for depicting the distribution of vegetation over relatively large areas.

J.1.2 Proposed Project

Descriptions of vegetation types and their distribution in the regions around the proposed project features are presented in this section. Except as noted, the discussions are based principally on plant ecology studies conducted for the Applicant by McKendrick et al. (1982) during the summers of 1980 and 1981.

Vegetation maps for most of the areas that would be affected by the proposed project were prepared by McKendrick et al. (1982) at three different scales. The entire upper and middle Susitna Basin area was mapped at a scale of 1:250,000 (Exhibit E, Vol. 6B, Chap. 3, Fig. E.3.38). The area within 10 miles (mi) [16 kilometers (km)] of either bank of the Susitna River between Gold Creek and the Tyone River also was mapped at a scale of 1:63,360 (Fig. J-2), as were the proposed access corridors and the 5-mi (8-km) wide Healy-to-Fairbanks and Willow-to-Anchorage power transmission corridor study areas (Exhibit E, Vol. 6B, Chap. 3, Figs. E.3.42 - E.3.44 and E.3.48 - E.3.52). Vegetation within the impoundment areas [and a 0.5-mi (0.8-km) zone surrounding the impoundment areas], construction and borrow areas, and the Susitna floodplain downstream of the dam sites to Talkeetna was further mapped at a scale of 1:24,000 (Exhibit E, Vol. 6B, Chap. 3, Figs. E.3.53 - E.3.65). Mapping was based on photo-interpretation of high-altitude (U-2) color infrared photography and LANDSAT imagery, followed by field verification. McKendrick et al. (1982) did not map vegetation along the route of the proposed Healy-to-Willow transmission corridor segment. Maps prepared by Commonwealth Associates (1982) at a scale of 1:250,000 were used to determine vegetation distributions within the vicinity of this segment.

Vegetation types were identified and delineated on the maps generated by McKendrick et al. (1982) according to the hierarchical classification system proposed by Viereck and Dyrness (1980). This classification system has five levels of resolution. Level I consists of five vegetation formations (forest, tundra, shrubland, and herbaceous terrestrial vegetation, and aquatic vegetation). At the finest level of resolution, Level V, the units are discrete plant communities. The three remaining levels are intermediate in resolution. Generally, Level III names were used for mapping, although Level IV names were often used for forest types, and Level I and II names were used for herbaceous types on the 1:24,000- and 1:63,360-scale maps. Additionally, shrubland types were identified by a combination of Level II and Level IV names. The general criteria used to place various vegetation types into the classes used by McKendrick et al. (1982) are briefly described in Table J-2.

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*Throughout this document, references to specific "Exhibits" are to the exhibits submitted to FERC as part of Alaska Power Authority's Susitna Hydroelectric Project License Application. References to specific "Appendices" (App.) are to the appendices provided in Volumes 2 through 7 of this Draft Environmental Impact Statement.

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Figure J-1. General Vegetation Distribution in Southcentral Alaska and Locations of Proposed Dam Sites, Non-Susitna Alternative Hydropower Sites, and Alternative Thermal Unit Sites. [Source: Adapted from Selkregg, 1974; 1977]

Table J-1. Descriptions of Generalized Vegetation Classes Used for Mapping in Figure J-1

Vegetation Class	Important Species	Description
Coastal Western Hemlock-Sitka Spruce Forest	Sitka spruce (*Picea sitchensis*) Western hemlock (*Tsuga heterophylla*) Mountain hemlock (*Tsuga mertensiana*) Balsam poplar (*Populus balsamifera*) Black cottonwood (*Populus trichocarpa*)	Extension of Pacific rainbelt forests; mountain hemlock replaces western hemlock in Cook Inlet area; west of Cook Inlet Sitka spruce dominates; deciduous hardwoods occur primarily on stream floodplains.
Bottomland Spruce-Poplar Forest	White spruce (*Picea glauca*) Balsam poplar Black cottonwood Paper birch (*Betula papyrifera*) Quaking aspen (*Populus tremuloides*)	Tall, relatively dense forests (and the successional stages leading to them) found on level to nearly level floodplains, low river terraces, and deeply thawed south-facing slopes; balsam poplar and cottonwood quickly invade floodplains following pioneer and alder-shrub stages; white spruce replaces hardwoods in later seral stages.
Upland Spruce-Hardwood Forest	White spruce Black spruce (*Picea mariana*) Paper birch Quaking aspen Balsam poplar	Varied forest types depending on conditions; successional stages often present due to fire; mixed white spruce-deciduous stands occur on south-facing slopes and well-drained soils; black spruce often replaces white spruce on north-facing slopes and on other cold or poorly drained soils; pure stands of white spruce or mixed white spruce-balsam poplar often occur along streams; pure stands of paper birch or aspen occur as successional stages following fire on warmer well-drained soils.
Lowland Spruce-Hardwood Forest	Black spruce White spruce Paper birch Quaking aspen Balsam poplar	Forests usually dominated by black spruce, sometimes in extensive pure stands; successional stages often present due to fire; occurs on areas of shallow peat, glacial deposits, outwash plains, intermontane basins, lowlands, and north-facing slopes; stands often underlain by permafrost; organic layer often well-developed.

Table J-1. (Continued)

Vegetation Class	Important Species	Description
High Brush	Sitka alder (Alnus sinuata) American green alder (Alnus crispa) Thinleaf alder (Alnus tenuifolia) Willows (Salix spp.) Resin birch (Betula glandulosa)	Occurs as three subtypes; coastal alder thickets are found between beach and forest along the southern coast of the Alaska Peninsula and eastern Cook Inlet; floodplain thickets dominated by willow and alder occur on alluvial deposits in rivers and along meandering streams; birch-alder-willow thickets occur between treeline and tundra, in avalanche paths, and old forest burn areas in interior Alaska.
Low Brush, Muskeg-Bog	Black spruce Sedges (Carex spp.) Mosses (Sphagnum and others) Cottongrasses (Eriophorum spp.) Bog rosemary (Andromeda polifolia) Resin birch Dwarf Arctic birch (Betula nana) Labrador tea (Ledum groenlandicum) Willows Bog cranberry (Oxycoccus microcarpus) Blueberries (Vaccinium spp.) Crowberry (Empetrum nigrum)	Muskeg-bogs usually consist of a thick mat of mosses, sedges, lichens, and dwarf shrubs; shrubs dominate exposed and drier sites, and mosses and herbaceous species dominate waterlogged areas; coastal muskegs found in wet, flat basins on the Kenai Peninsula and bordering upper Cook Inlet often have conifers (western hemlock and Alaska cedar) scattered over drier areas; interior bogs often occur where conditions are too wet for trees, although scattered black spruce do occur on drier areas; string bogs have unevenly spaced string-like ridges that are often too wet for shrubs.
Moist Tundra	Cottongrass Polar grass (Arctagrostis latifolia) Bluejoint (Calamagrostis canadensis) Sedges Dwarf Arctic birch Resin birch Willows Labrador tea Blueberries Bearberry (Arctostaphylos spp.) Crowberry Bog cranberry	Community composition varies from almost continuous cottongrass tussocks with sparse growth of sedges and dwarf shrubs to stands in which dwarf shrubs are dominant and tussocks are scarce or absent.

Table J-1. (Continued)

Vegetation Class	Important Species	Description
Wet Tundra	Cottongrass Sedges Rushes (*Juncus* spp.) Willows Dwarf Arctic birch Labrador tea Mountain cranberry (*Vaccinium vitis-idaea*)	Dominant species are sedges and cottongrass, which usually occur in a mat rather than in tussocks; woody and herbaceous species are infrequent and occur above the water table; found in low, flat areas where soils are wet and shallow lakes are common.
Alpine Tundra	Mountain avens (*Dryas* spp.) Moss campion (*Silene acaulis*) Cassiopes (*Cassiope* spp.) Dwarf arctic birch Crowberry Labrador tea Alpine bearberry (*Arctostaphylos alpina*) Bog blueberry (*Vaccinium uliginosum*) Mountain heather (*Phyllodoce* spp.) Willows Alpine azalea (*Loiseleuria procumbens*)	Most common on ridges, rubble slopes, and other shallow, dry and porous soils in mountains at elevations between 2,000 and 4,000 ft; vegetation is sparse and only a few inches high; plant associations vary, but mountain avens and lichens usually dominate; associated herbs, grasses, and sedges occur as low mats.

Conversion: To convert feet to meters, multiply by 0.305.

Source: Based on Selkregg (1974, 1977) and Neiland and Viereck (1977).

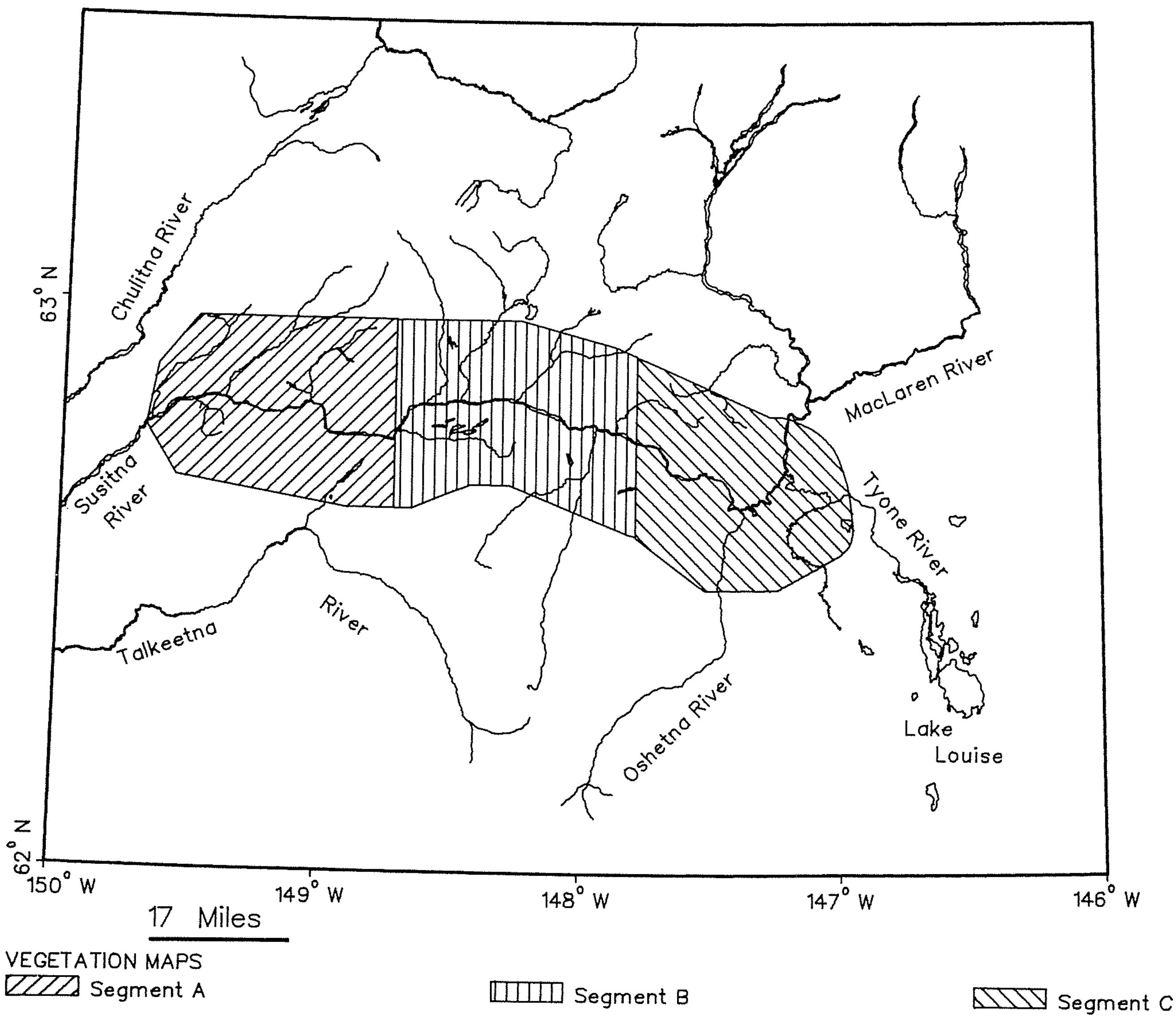


Figure J-2. Vegetation Distribution within 10 mi (16 km) of the Susitna River between Gold Creek and the Tyone River: Location Map. [Actual maps for Segments A, B, and C are inserted in the pocket inside the back cover.]

Table J-2. Summary of Viereck and Dyrness (1980) Vegetation Classifications Used for Vegetation Mapping†[1]

Level I	Level II	Level III
1. Forest Canopy cover of tree species ≧ 10%	1.1 Conifer Forest Conifer species contribute ≧ 75% of tree cover	1.1.1 Closed Conifer Forest†[2] Tree canopy cover > 50%
		1.1.2 Open Conifer Forest†[2] Tree canopy cover ranges 25%-50%
		1.1.3 Conifer Woodland Tree canopy cover ranges 10%-25%
	1.2 Deciduous Forest Deciduous species contribute ≧ 75% of tree cover	1.2.1 Closed Deciduous Forest†[2] Tree canopy cover > 50%
		1.2.2 Open Deciduous Forest†[2] Tree canopy cover ranges 25%-50%
		1.2.3 Deciduous Woodland Tree canopy cover ranges 10%-25%
	1.3 Mixed Forest Deciduous and conifer species each contribute 25%-74% of tree cover	1.3.1 Closed Mixed Forest†[2] Tree canopy cover > 50%
		1.3.2 Open Mixed Forest†[2] Tree canopy cover ranges 25%-50%
		1.3.3 Mixed Woodland Tree canopy cover ranges 10%-25%

Table J-2. (Continued)

Level I	Level II	Level III
2. Shrubland Vegetation dominated by erect to decumbent (but not matted) woody shrubs; cover of shrub species ≥ 25%; not located beyond tree line	2.1 Tall Shrubland Shrubs > 5 ft tall	2.1.1 Closed Tall Shrubland Canopy cover of shrub species > 75%
		2.1.2 Open Tall Shrubland Canopy cover of shrub species ranges 25%-75%
	2.2 Low Shrubland Shrubs < 5 ft tall; shrubs not associated with tundra species; located adjacent to tree line or within forested regions	2.2.1 Closed Low Shrubland Canopy cover of shrub species > 75%
		2.2.2 Open Low Shrubland Canopy cover of shrub species ranges 25%-75%
3. Tundra Vegetation dominated by sedges and low, matted shrubs; if grasses dominate they are typical Arctic species (e.g., *Arctagrostis latifolia* or *Poa arctica*); located above tree line	3.1 Sedge-Grass Tundra Vegetation dominated by a sedge-grass mat, not forming tussocks	3.1.1 Wet Sedge-Grass Tundra Vegetation dominated by sedges and grasses common to wet sites; cover of erect shrub species < 10%
		3.1.2 Mesic Sedge-Grass Tundra Vegetation dominated by sedges, grasses, or forbs common to mesic sites; cover of low or matted shrub species < 10%
	3.2 Mat and Cushion Tundra Vegetation dominated by herbaceous species and prostrate shrubs (e.g., *Betula nana* and *Dryas*) usually ≤ 8 to 12 in tall	3.2.1 Closed Mat and Cushion Tundra Areal cover > 75%
		3.2.2 Open Mat and Cushion Tundra Areal cover generally ranges 50%-75%

Table J-2. (Continued)

Level I	Level II	Level III
	3.3 Herbaceous Tundra Vegetation dominated by forbs	3.3.1 Alpine Herbaceous Tundra Located on snowbeds, cliffs, and scree slopes in alpine areas; species composition is very diverse
4. Herbaceous Vegetation Vegetation dominated by grasses (primarily Calamagrostis and Elymus), or pioneer communities on gravel and sand bars in rivers	4.1 Tall Grassland Grasses dominate but occasional forbs and sedges; grasses > 3.3 ft tall	N.A.†3

†1 Vegetation maps usually use Level III classifications, except Level IV is often used for forest types (e.g., black spruce, white spruce, birch, balsam poplar) and shrubland (e.g., willow, birch); whereas Level I and II are used for herbaceous types.

†2 Viereck and Dyrness (1980) proposed 60% cover as the boundary between closed and open forest types, but McKendrick et al. (1982) used 50% cover because it was easier to estimate on aerial photographs and in the field.

†3 Not applicable.

Conversions: To convert feet to meters, multiply by 0.305.
To convert inches to centimeters, multiply by 2.54.

Source: Based on Viereck and Dyrness (1980) and McKendrick et al. (1982).

Major vegetation types and subtypes (defined by important species) found within the upper and middle Susitna Basin, lower Susitna River floodplain, and transmission corridor study areas, and descriptions of the general kinds of areas where these vegetation types usually occur are listed in Table J-3. Each of these vegetation types is described in more detail in Section J.1.2.1.

The Viereck and Dyrness (1980) vegetation types do not correspond directly to the classification system used in Figure J-1 and also in Commonwealth Associates (1982) for the Healy-to-Willow transmission corridor segment. To provide some basis for comparison between the two systems, the Viereck and Dyrness (1980) vegetation types that are most likely to occur within the vegetation classes shown in Figure J-1 are identified in Table J-4.

Potential wetland areas were quantified by liberally correlating appropriate Viereck and Dyrness (1980) vegetation types to the wetland classes of Cowardin et al. (1979) as indicated in Table J-5. Although estimates of potential wetland area and distribution obtained by this method are extremely liberal, they are the best currently available.

Floristics surveys of the upper and middle Susitna Basin and the lower Susitna River floodplain were conducted by McKendrick et al. (1982). Additional species occurrences in the upper and middle Susitna Basin were also reported by Steigers et al. (1983). Floristics surveys of the Healy-to-Willow transmission corridor study area were made by Commonwealth Associates (1982). The Willow-to-Anchorage and Healy-to-Fairbanks transmission corridor study areas were not surveyed.

To date, 307 vascular plant species belonging to 154 genera in 58 families have been identified by the Applicant in the upper and middle Susitna Basin, the lower Susitna River floodplain, and the Healy-to-Willow transmission corridor study area (Table J-6). There was considerable overlap in the species composition of the various survey areas. In the upper and middle basin, 263 species were identified, 80 and 128 species were found in the lower Susitna River floodplain downstream of Gold Creek and in the Healy-to-Willow transmission corridor study area, respectively. However, of these 80 and 128 species, only 26 and 18, respectively, were species not already found in the upper and middle Susitna basin. In surveys for nonvascular plants, 11 lichen genera (including at least 12 species) and seven moss taxa were identified in the upper and middle basin and the lower Susitna River floodplain (Table J-6). McKendrick et al. (1982) indicated that the work on mosses and lichens was not extensive and that many more species would likely be identified with additional work.

In general, the vegetation communities in the vicinity of the proposed project area are typical of those found over much of Interior Alaska, including mountainous areas. Many of these communities represent various successional stages that are often the result of fires or river action (Van Cleve and Viereck, 1981; Van Cleve et al., 1983). Descriptions of specific vegetation types are provided below for the upper and middle Susitna Basin. For the lower Susitna River floodplain, vegetation consists of various successional stages of mixed conifer-deciduous forest, and these stages are described. Discussions of vegetation types within the proposed transmission corridor study areas are broken down by corridor segments. The areas covered by wetlands within each geographic region are also discussed.

J.1.2.1 Upper and Middle Susitna River Basin

The distribution of vegetation types within the entire upper and middle Susitna Basin is illustrated in Exhibit E (Vol. 6B, Chap. 3, Fig. E.3.38). Along the east-west portion of the Susitna River, the often steep canyon slopes are covered with conifer, deciduous, or mixed conifer-deciduous forests. Above the canyons, the terrain changes to relatively flat benches, and the vegetation consists primarily of low shrub (birch or willow) or woodland spruce communities. Alder-dominated tall shrub communities are most common along creek and river drainages, especially on the western end of the middle Susitna Basin. At the higher elevations, including low mountains rising above the benches, predominant vegetation types are mesic sedge-grass tundra or mat and cushion tundra.

In the upper Susitna Basin, vegetation types are primarily low shrub (birch and willow) and woodland spruce. Tundra systems are present at the higher elevations. Mat and cushion and mesic sedge-grass tundra occur over areas large enough to be mapped at the 1:250,000 scale used in Figure E.3.38 of Exhibit E (Vol. 6B, Chap. 3). However, many of the areas mapped as rock also have important pioneering plant species growing in soil pockets and small crevices, but these plants provide negligible ground cover. Most of the far northern reaches of the upper basin, in the Alaska Range, are covered by permanent snowfields and glaciers and, thus, lack vegetation cover.

The southeastern portion of the middle Susitna Basin in the area of the Oshetna and Tyone rivers and Lake Louise is characterized by extensive flat areas. Predominant vegetation types are low shrubland (birch and willow), as well as woodland black spruce and open spruce forests. Much of the area is poorly drained and bog-like.

Table J-3. Vegetation Types and Their General Areas of Occurrence within the Upper and Middle Susitna Basin, Lower Susitna River Floodplain, and Transmission Corridor Study Area†[1]

Vegetation Type	Important Species (subtype)	Occurrence
Conifer Forest		
Conifer species contribute ≧ 75% of tree cover	Black spruce (Picea mariana)	Poorly drained sites, including those underlain by permafrost and those on north-facing slopes
	White spruce (Picea glauca)	Warmer, well-drained sites
Deciduous Forest		
Deciduous species contribute ≧75% of tree cover	Balsam poplar (Populus balsamifera)	Islands in the rivers or flat areas in the floodplain
	Paper birch (Betula papyrifera)	Steep, relatively dry, usually south-facing slopes
	Trembling aspen (Populus tremuloides)	Upper levels of dry, south-facing slopes; usually on drier, warmer sites than paper birch; stands small and infrequent
Mixed Forest		
Deciduous and conifer species each contribute 25%-74% of tree cover	White spruce/paper birch	Considered a successional stage where white spruce is replacing deciduous forest; usually on slopes along the river
	White spruce/hardwoods	Considered a stage in floodplain succession where mature balsam poplar is being replaced by white spruce and paper birch on the oldest, most stable sites
Tall Shrubland		
Shrubs > 5 ft tall	Sitka alder (Alnus sinuata) American green alder (Alnus crispa)	Usually in narrow strips through other vegetation types on slopes along rivers and creeks and in rings around mountains at certain elevations
Low Shrubland		
Shrubs < 5 ft tall; shrubs not associated with tundra species	Resin birch (Betula glandulosa)	On relatively flat benches with soils that are frequently wet and gleyed, but usually without standing water; located adjacent to tree line or within forested regions

Table J-3. (Continued)

Vegetation Type	Important Species (subtype)	Occurrence
	Diamondleaf willow (*Salix planifolia* ssp. *pulchra*)	Similar but wetter sites than birch shrub; sites often have standing water; often found in thickets along small streams at high elevations
Wet Sedge-Grass Tundra		
Shrub layer of scattered willows present in some stands	Water sedge (*Carex aquatilis*) Bigelow sedge (*Carex bigelowii*) Bluejoint (*Calamagrostis canadensis*) Sphagnum mosses (*Sphagnum* spp.)	Wet, depressed areas with poor drainage; more common below tree line than other tundra types
Mesic Sedge-Grass Tundra		
Vegetation usually < 1 ft tall	Bigelow sedge	Rolling uplands with well-drained soils
Mat and Cushion Tundra		
Vegetation usually < 8 to 12 in tall	Lichens Dwarf arctic birch (*Betula nana*) Crowberry (*Empetrum nigrum*) Bearberry (*Arctostaphylos* spp.) Bog blueberry (*Vaccinium uliginosum*) Northern Labrador tea (*Ledum decumbens*)	Dry, windy ridges
Alpine Herbaceous Tundra	Herb-sedge (species composition is very diverse, no dominants)	Near glaciated areas on gentle, well-drained slopes at high elevations
	Pioneer forbs and shrubs	Small soil pockets between rocks in isolated rocky areas
Herbaceous Types	Bluejoint (*Calamagrostis canadensis*)	Grassland communities on level to sloping areas at lower elevations near the rivers
	Horsetails (*Equisetum* spp.) Lupines (*Lupinus* spp.) Alpine sweetvetch (*Hedysarum alpinum*)	Pioneer communities on gravel and sand bars in rivers

†[1] See Section J.1.2.1 for more detailed discussions of the information in this table.

Conversions: To convert feet to meters, multiply by 0.305.
To convert inches to centimeters, multiply by 2.54.

Source: Based on Viereck and Dyrness (1980) and McKendrick et al. (1982).

Table J-4. Viereck and Dyrness (1980) Vegetation Types Most Likely to Occur within the Vegetation Classes Delineated in Figure J-1

Vegetation Class†[1]	Vegetation Types†[2]
Coastal western hemlock-Sitka spruce forest	N.A.†[3]
Bottomland spruce-poplar forest	Balsam poplar forest, white spruce forest, mixed forest, tall shrubland, herbaceous
Upland spruce-hardwood forest	White spruce forest, black spruce forest, birch forest, aspen forest, mixed forest, low shrubland, tall shrubland
Lowland spruce-hardwood forest	Black spruce forest, low shrubland
High brush	Tall shrubland, low shrubland
Low brush, muskeg bog	Low shrubland, black spruce forest, wet sedge-grass tundra
Moist tundra	Mat and cushion tundra, mesic sedge-grass tundra, low shrubland
Wet tundra	Wet sedge-grass tundra
Alpine tundra	Alpine herbaceous tundra, mat and cushion tundra, mesic sedge-grass tundra

†[1] Classification system used in Figure J-1 and described in Table J-1. Based on Selkregg (1974, 1977) and Neiland and Viereck (1977).

†[2] Viereck and Dyrness (1980) vegetation types and subtypes identified in Table J-3.

†[3] N.A. = Not applicable. Coastal forests did not occur within Susitna Basin or transmission corridor study area.

Source: Based on Selkregg (1974, 1977); Neiland and Viereck (1977); and Viereck and Dyrness (1980).

Table J-5. Correlation of Vegetation Classes to Potential Wetland Classes

Vegetation Class†[1]	U.S. Fish and Wildlife Service Wetland Class†[2]
Lakes, ponds	Lacustrine unconsolidated bottom, aquatic bed, and unconsolidated shore
Rivers, streams	Riverine upper perennial rock bottom, unconsolidated bottom, rocky shore, and unconsolidated shore
Wet sedge-grass	Palustrine or lacustrine emergent, persistent
Low shrub	Palustrine scrub-shrub, broad-leaved deciduous
Birch shrub	Palustrine scrub-shrub, broad-leaved deciduous
Willow shrub	Palustrine scrub-shrub, broad-leaved deciduous
Open black spruce	Palustrine forested, needle-leaved evergreen
Woodland black spruce	Palustrine forested, needle-leaved evergreen
Open white spruce	Palustrine forested, needle-leaved evergreen
Woodland white spruce	Palustrine forested, needle-leaved evergreen
Open balsam poplar	Palustrine forested, broad-leaved deciduous
Closed balsam poplar	Palustrine forested, broad-leaved deciduous

†[1] Based on Viereck and Dyrness (1980).

†[2] Based on Cowardin et al. (1979).

Source: Modified from McKendrick et al. (1982).

Table J-6. Preliminary List of Plant Species Identified in the Upper and Middle Susitna River Basin, the Downstream Floodplain, and the Healy-to-Willow Transmission Corridor Study Area

Scientific Name†[1]	Common Name	Location†[2]
PTERIDOPHYTA		
Aspidiaceae		
Dryopteris dilatata (Hoffm.) Gray	Shield fern	U D I
Dryopteris fragrans (L.) Schott	Fragrant shield fern	U I
Gymnocarpium dryopteris (L.) Newm.	Oak fern	U D I
Athyriaceae		
Athyrium filix-femina (L.) Roth	Lady fern	U D
Cystopteris fragilis (L.) Bernh.	Fragile fern	U
Cystopteris montana (Lam.) Bernh.	Mountain fragile fern	U
Matteuccia struthiopteris (L.) Todaro	Ostrich fern	D I
Woodsia alpina (Bolton) S.F. Gray	Alpine woodsia	U
Equisetaceae		
Equisetum arvense L.	Meadow horsetail	U
Equisetum fluviatile L. ampl. Ehrh.	Swamp horsetail	U
Equisetum palustre L.	Marsh horsetail	D
Equisetum pratense L.	Meadow horsetail	U D
Equisetum silvaticum L.	Woodland horsetail	U I
Equisetum variegatum Schleich.	Variegated scouring-rush	U D
Equisetum sp.	Horsetail	I
Isoetaceae		
Isoetes muricata Dur.	Quillwort	U
Lycopodiaceae		
Lycopodium alpinum L.	Alpine clubmoss	U
Lycopodium annotinum L.	Stiff clubmoss	U
Lycopodium clavatum L.	Running clubmoss	U
Lycopodium complanatum L.	Ground cedar	U
Lycopodium selago L. ssp. *selago*	Fir clubmoss	U
Thelypteridaceae		
Thelypteris phegopteris (L.) Slosson	Long beech fern	U
GYMNOSPERMAE		
Cupressaceae		
Juniperus communis L.	Common juniper	U I
Pinaceae		
Picea glauca (Moench) Voss	White spruce	U D I
Picea mariana (Mill.) Britt., Sterns & Pogg.	Black spruce	U I
MONOCOTYLEDONEAE		
Cyperaceae		
Carex aquatilis Wahlenb.	Water sedge	U
Carex bigelowii Torr.	Bigelow sedge	U
Carex capillaris L.	Hairlike sedge	U
Carex canescens L.	Silvery sedge	U D I
Carex concinna R. Br.	Low northern sedge	U
Carex eleusinoides Turcz.	Sedge	D
Carex filifolia Nutt.	Thread-leaf sedge	U
Carex garberi Fern.	Sedge	D
Carex limosa L.	Shore sedge	U
Carex loliacea L.	Sedge	U
Carex magellanica Lam. ssp. *irrigua* (Wahlenb.) Hult.	Bog sedge	U
Carex media R. Br.	Sedge	U
Carex membranacea Hook.	Fragile sedge	U
Carex podocarpa C.B. Clarke	Short-stalk sedge	U

Table J-6. (Continued)

Scientific Name†[1]	Common Name	Location†[2]
Carex rhynchophysa C.A. Mey.	Sedge	U
Carex rotundata Wahlenb.	Sedge	D
Carex saxatilis L.	Sedge	D
Carex spp.	Sedge	U D I
Eleocharis sp.	Spike rush	I
Eriophorum angustifolium Honck.	Tall cottongrass	U
Eriophorum scheuchzeri Hoppe	White cottongrass	U
Eriophorum vaginatum L.	Tussock cottongrass	U D I
Eriophorum sp.	Cottongrass	D I
Scirpus microcarpus Presl.	Small-fruit bullrush	D
Trichophorum caespitosum (L.) Hartm.	Tufted clubrush	U
Gramineae (Poaceae)		
Agropyron boreale (Turcz.) Drobov	Northern wheatgrass	D
Agropyron caninum (L.) Beauv.	Wheatgrass	D
Agropyron macrourum (Turcz.) Drobov	Wheatgrass	D
Agropyron sp.	Wheatgrass	U
Agrostis scabra Willd.	Tickle grass	U D
Agrostis sp.	Bent grass	U
Alopecurus alpinus Sm.	Mountain foxtail	U
Arctagrostis latifolia (R. Br.) Griseb.	Polargrass	U
Beckmannia syzigachne (Steud.) Fern.	Slough grass	D
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint	U D I
Calamagrostis purpurascens R. Br.	Purple reedgrass	U
Cinna latifolia (Trev.) Griseb. in Ledeb.	Woodreed	D
Danthonia intermedia Vasey	Timber oatgrass	U
Deschampsia atropurpurea (Wahlenb.) Scheele†[3]	Mountain hairgrass	U
Deschampsia caespitosa (L.) Beauv.	Tufted hairgrass	U D
Festuca altaica Trin.	Fescue grass	U
Festuca rubra L. Coll.	Red fescue	U
Hierochloe alpina (Swartz) Roem. & Schult.	Alpine holygrass	U
Hierochloe odorata (L.) Wahlenb.	Vanilla grass	U D
Phleum commutatum Gandoger	Timothy	U
Poa alpina L.	Alpine bluegrass	U
Poa arctica R. Br.	Arctic bluegrass	U
Poa palustris L.	Bluegrass	U
Trisetum spicatum (L.) Richter	Downy oatgrass	U D
Iridaceae		
Iris setosa Pellas	Wild iris	U I
Juncaceae		
Juncus arcticus Willd.	Arctic rush	U D
Juncus castaneus Sm.	Chestnut rush	U
Juncus drummondii E. Mey.	Drummond rush	U
Juncus mertensianus Bong.	Mertens rush	U
Juncus triglumis L.	Rush	U
Luzula campestris (L.) DC. ex DC. & Lam†[3]	Woodrush	U
Luzula confusa Lindeb.	Northern woodrush	U
Luzula multiflora (Retz.) Lej.	Woodrush	U
Luzula parviflora (Ehrh.) Desv.	Small-flowered woodrush	U
Luzula tundricola Gorodk.	Tundra woodrush	U
Luzula wahlenbergii Rupr.	Wahlenberg woodrush	U
Liliaceae		
Lloydia serotina (L.) Rchb.	Alp lily	U I
Streptopus amplexifolius (L.) DC.	Cucumber root	U D I
Tofieldia coccinea Richards.	Northern asphodel	U
Tofieldia pusilla (Michx.) Pers.	Scotch asphodel	U I
Veratrum viride Ait.	False hellebore	U I
Zygadenus elegans Pursh	Elegant death camas	U I
Orchidaceae		
Listera cordata (L.) R. Br.	Twyblade	I
Platanthera convallariaefolia (Fisch.) Lindl.	Northern bog-orchis	U

Table J-6. (Continued)

Scientific Name†[1]	Common Name	Location†[2]
Platanthera dilatata (Pursh) Lindl.	White bog-orchis	U
Platanthera hyperborea (L.) Lindl.	Northern bog-orchis	U I
Platanthera obtusata (Pursh) Lindl.	Small bog-orchis	U
Potamogetomaceae		
Potamogeton epihydrus Raf.	Nuttall pondweed	U
Potamogeton filiformis Pers.	Filiform pondweed	U
Potamogeton gramineus L.	Pondweed	U
Potamogeton perfoliatus L.	Clasping-leaf pondweed	U
Potamogeton robbinsii Oakes	Robbins pondweed	U
Sparganiaceae		
Sparganium angustifolium Michx.	Narrow-leaved burreed	U
DICOTYLEDONEAE		
Adoxaceae		
Adoxa moschatellina L.	Moschatel	D
Araliaceae		
Echinopanax horridum (Sm.) Decne. & Planch.	Devil's club	U D I
Betulaceae†[4]		
Alnus crispa (Ait.) Pursh	American green alder	U I
Alnus sinuata (Reg.) Rydb.	Sitka alder	U D I
Alnus tenuifolia Nutt.	Thinleaf alder	D
Alnus sp.	Alder	I
Betula glandulosa Michx.	Resin birch	U I
Betula nana L.	Dwarf arctic birch	U D I
Betula occidentalis Hook.	Water birch	U
Betula papyrifera Marsh.	Paper birch	U D I
Boraginaceae		
Mertensia paniculata (Ait.) G. Don	Tall bluebell	U D I
Myosotis alpestris F.W. Schmidt	Forget-me-not	U
Callitrichaceae		
Callitriche hermaphroditica L.	Water starwort	U
Callitriche verna L.	Vernal water starwort	U
Campanulaceae		
Campanula lasiocarpa Cham.	Mountain harebell	U I
Caprifoliaceae		
Linnaea borealis L.	Twin-flower	U I
Sambucus callicarpa Greene†[4]	Pacific red elder	I
Viburnum edule (Michx.) Raf.	High bush cranberry	U D I
Caryophyllaceae		
Minuartia obtusiloba (Rydb.) House	Alpine sandwort	U
Moehringia lateriflora (L.) Fenzl	Grove sandwort	D I
Silene acaulis L.	Moss campion	U
Stellaria crassifolia Ehrh.	Chickweed	I
Stellaria sp.	Starwort	U
Wilhelmsia physodes (Fisch.) McNeill	Merckia	U
Compositae (Asteraceae)		
Achillea borealis Bong.	Yarrow	U D
Achillea sibirica Ledeb.	Siberian yarrow	U D
Antennaria alpina (L.) Gaertn.	Alpine pussytoes	U
Antennaria monocephala DC.	Pussytoes	U
Antennaria rosea Greene	Pussytoes	U
Arnica amplexicaulis Nutt. ssp. *prima* Maguire	Arnica	U
Arnica chamissonis Less. (?)	Arnica	D
Arnica frigida C.A. Mey.	Arnica	U I
Arnica lessingii Greene	Arnica	U

Table J-6. (Continued)

Scientific Name†[1]	Common Name	Location†[2]		
Artemisia alaskana Rybd.	Alaska wormwood	U		
Artemisia arctica Less.	Wormwood	U		I
Artemisia tilesii Ledeb.	Wormwood	U	D	I
Aster sibiricus L.	Siberian aster	U	D	I
Erigeron acris ssp. *politus* (L.) (E. Fries) Schinz & Keller	Fleabane			I
Erigeron humilis Graham	Fleabane daisy	U		
Erigeron lonchophyllus Hook.	Daisy		D	
Erigeron purpuratus Greene	Fleabane			I
Hieracium triste Willd.	Wooly hawkweed	U		
Petasites frigidus (L.) Franch.	Arctic sweet coltsfoot	U		I
Petasites sagittatus (Banks) Gray	Arrowleaf sweet coltsfoot	U		
Petasites sp.	Sweet coltsfoot		D	I
Saussurea angustifolia (Willd.) DC.	Saussurea	U		I
Senecio atropurpureus (Ledeb.) Fedtsch.	Ragwort	U		
Senecio lugens Richards.	Ragwort	U		I
Senecio sheldonensis Pors.	Sheldon groundsel	U		
Senecio triangularis Hook.	Ragwort			I
Senecio sp.	Ragwort			I
Solidago multiradiata Ait.	Northern goldenrod	U	D	
Taraxacum sp.	Dandelion	U		
Cornaceae				
Cornus canadensis L.	Bunchberry	U	D	I
Crassulaceae				
Sedum rosea (L.) Scop.	Roseroot	U		I
Cruciferae (Brassicaceae)				
Cardamine bellidifolia L.	Alpine bittercress	U		
Cardamine pratensis L.	Cuckoo flower	U		
Cardamine umbellata Greene	Bittercress	U		
Draba aurea Vahl	Draba			I
Draba nivalis Liljebl.	Rockcress	U		
Draba stenoloba Ledeb.	Rockcress	U		
Parrya nudicaulis (L.) Regel	Mustard	U		I
Rorippa islandica (Oeder) Borb.	Marsh yellowcress	U		
Diapensiaceae				
Diapensia lapponica L.	Diapensia	U		I
Droseraceae				
Drosera rotundifolia L.	Sundew			I
Elaeagnaceae				
Shepherdia canadensis (L.) Nutt.	Soapberry	U	D	I
Empetraceae				
Empetrum nigrum L.	Crowberry	U		I
Ericaceae				
Andromeda polifolia L.	Bog rosemary	U		
Arctostaphylos alpina (L.) Spreng.	Alpine bearberry	U		I
Arctostaphylos rubra (Rehd. & Wilson) Fern.	Red-fruit bearberry	U		I
Arctostaphylos uva-ursi (L.) Spreng.	Bearberry	U		I
Cassiope stelleriana (Pall.) DC.	Alaska moss heath	U		
Cassiope tetragona (L.) D. Don	Four-angle mountain heather	U		I
Ledum decumbens (Ait.) Small†[4]	Northern Labrador tea	U		I
Ledum groenlandicum Oeder	Labrador tea	U		I
Ledum sp.	Labrador tea		D	I
Loiseleuria procumbens (L.) Desv.	Alpine azalea	U		I
Menziesia ferruginea Sm.	Menziesia			I
Oxycoccus microcarpus Turcz.	Bog cranberry	U	D	
Rhododendron lapponicum (L.) Wahlenb.	Lapland rosebay	U		I
Vaccinium caespitosum Michx.	Dwarf blueberry	U		
Vaccinium uliginosum L.	Bog blueberry	U	D	I
Vaccinium vitis-idaea L.	Mountain cranberry	U		I
Vaccinium sp.	Blueberry			I

Table J-6. (Continued)

Scientific Name†[1]	Common Name	Location†[2]
Fumariaceae		
Corydalis pauciflora (Steph.) Pers.	Few-flowered corydalis	U I
Gentianaceae		
Gentiana glauca Pall.	Glaucous gentian	U
Gentiana propinqua Richards.	Gentian	U
Menyanthes trifoliata L.	Buckbean	U D I
Swertia perennis L.	Gentian	U I
Geraniaceae		
Geranium erianthum DC.	Northern geranium	U I
Haloragaceae		
Hippuris vulgaris L.	Common marestail	U
Leguminosae (Fabaceae)		
Astragalus aboriginum Richards.	Milk-vetch	U
Astragalus alpinus L.†[3]	Milk-vetch	U D
Astragalus umbellatus Bunge	Milk-vetch	U
Hedysarum alpinum L.	Alpine sweet-vetch	U D I
Lupinus arcticus S. Wats.	Arctic lupine	U I
Oxytropis borealis DC.	Oxtrope	D
Oxytropis campestris (L.) DC.	Field oxytrope	D
Oxytropis huddelsonii Pors.	Huddelson oxytrope	U
Oxytropis maydelliana Trautv.	Maydell oxytrope	U
Oxytropis nigrescens (Pall.) Fisch.	Blackish oxytrope	U I
Oxytropis viscida Nutt.	Viscid oxytrope	U
Lentibulariaceae		
Pinguicula villosa L.	Hairy butterwort	U
Utricularia vulgaris L.	Common bladderwort	U
Myricaceae		
Myrica gale L.	Sweet gale	U D I
Nymphaeaceae		
Nuphar polysepalum Engelm.	Yellow pond lily	U
Onagraceae		
Circaea alpina L.	Enchanter's nightshade	D
Epilobium angustifolium L.	Fireweed	U D I
Epilobium latifolium L.	Dwarf fireweed	U D I
Epilobium palustre L.	Swamp willow-herb	U
Orobanchaceae		
Boschniakia rossica (Cham. & Schlecht.) Fedtsch.	Poque	U D I
Polemoniaceae		
Polemonium acutiflorum Willd.	Jacob's ladder	U D I
Polygonaceae		
Oxyria digyna (L.) Hill	Mountain sorrel	U I
Polygonum bistorta L.	Meadow bistort	U
Polygonum viviparum L.	Alpine bistort	U I
Rumex arcticus Trautv.	Arctic dock	U I
Rumex sp.	Dock	U I
Portulacaceae		
Claytonia sarmentosa C.A. Mey.	Spring-beauty	U I
Primulaceae		
Androsace chamaejasme Hult.	Rock jasmine	I
Dodecatheon frigidum Cham. & Schlecht.	Northern shooting star	U I
Primula cuneifolia Ledeb.	Wedge-leaf primrose	U
Primula egaliksensis Wormsk.	Greenland primrose	U
Trientalis europaea L.	Arctic starflower	U D I

Table J-6. (Continued)

Scientific Name†[1]	Common Name	Location†[2]
Pyrolaceae		
Moneses uniflora (L.) Gray	Single delight	U D
Pyrola asarifolia Michx.	Liverleaf wintergreen	D
Pyrola grandiflora Radius	Large-flower wintergreen	U
Pyrola minor L.	Lesser wintergreen	U
Pyrola secunda L.	One-sided wintergreen	U D
Pyrola sp.	Wintergreen	I
Ranunculaceae		
Aconitum delphinifolium DC.	Monkshood	U I
Actaea rubra (Ait.) Willd.	Baneberry	D
Anemone narcissiflora L.	Anemone	U I
Anemone parviflora Michx.	Northern anemone	U I
Anemone richardsonii Hook.	Anemone	U D I
Anemone sp.	Anemone	I
Caltha leptosepala DC.	Mountain marsh-marigold	U I
Caltha palustris L.	Marsh marigold	U
Delphinium glaucum S. Wats.	Larkspur	I
Ranunculus confervoides (E. Fries) E. Fries	Water crowfoot	U
Ranunculus macounii Britt. (may be R. pacificus or something similar)	Macoun buttercup	D
Ranunculus nivalis L.	Snow buttercup	U
Ranunculus occidentalis Nutt.	Western buttercup	U
Ranunculus pygmaeus Wahlenb.	Pygmy buttercup	U
Ranunculus sp.	Buttercup	U I
Thalictrum alpinum L.	Arctic meadowrue	U
Thalictrum sparsiflorum Turcz.	Few-flower meadowrue	U D I
Rosaceae		
Dryas drummondii Richards.	Drummond mountain-avens	U D I
Dryas integrifolia M. Vahl	Dryas	U I
Dryas octopetala L.	White mountain-avens	U
Geum macrophyllum Wild.	Avens	I
Geum rossii (R. Br.) Ser.	Ross avens	U I
Luetkea pectinata (Pursh) Ktze.	Luetkea	U
Potentilla biflora Willd.	Two-flower cinquefoil	U
Potentilla fruticosa L.	Shrubby cinquefoil	U I
Potentilla hyparctica Malte	Arctic cinquefoil	U
Potentilla palustris (L.) Scop.	Marsh cinquefoil	U D I
Potentilla villosa Pall.	Villous cinquefoil	U
Rosa acicularis Lindl.	Prickly rose	U D I
Rubus arcticus L.	Nagoon berry	U D I
Rubus chamaemorus L.	Cloudberry	U I
Rubus idaeus L.	Raspberry	U D I
Rubus pedatus Sm.	Five-leaf bramble	U I
Rubus sp.	Raspberry	I
Sanguisorba stipulata Raf.	Sitka burnet	U I
Sibbaldia procumbens L.	Sibbaldia	U
Sorbus scopulina Greene	Western mountain ash	U I
Spiraea beauverdiana Schneid.	Beauverd spirea	U D I
Rubiaceae		
Galium boreale L.	Northern bedstraw	U I
Galium trifidum L.	Small bedstraw	U
Galium triflorum Michx.	Sweet-scented bedstraw	D
Salicaceae†[4]		
Populus balsamifera L.	Balsam poplar (or cottonwood)	U D I
Populus tremuloides Michx.	Quaking aspen	U I
Salix alaxensis (Anderss.) Cov.	Feltleaf willow	U D
Salix arbusculoides Anderss.	Littletree willow	U D
Salix arctica Pall.	Arctic willow	U
Salix barclayi Anderss.	Barclay willow	U
Salix brachycarpa Nutt.	Barren-ground willow	U
Salix fuscescens Anderss.	Alaska bog willow	U D

Table J-6. (Continued)

Scientific Name†[1]	Common Name	Location†[2]
Salix glauca L.	Grayleaf willow	U
Salix lanata L. ssp. *richardsonii* (Hook) A. Skwortz.	Richardson willow	U
Salix monticola Bebb.	Park willow	U
Salix novae-angliae Anderss.	Tall blueberry willow	U D
Salix phlebophylla Anderss.	Skeletonleaf willow	U
Salix planifolia Pursh ssp. *planifolia*	Planeleaf willow	U
Salix planifolia Pursh ssp. *pulchra* (Cham.) Argus	Diamondleaf willow	U
Salix polaris Wahlenb. ssp. *pseudopolaris* (Flod.) Hult.	Polar willow	U
Salix reticulata L.	Netleaf willow	U
Salix rotundifolia Trautv.	Least willow	U
Salix scouleriana Barratt	Scouler willow	U
Salix sp.	Willow	U D I
Santalaceae		
Geocaulon lividum (Richards.) Fern.	Sandalwood	U
Saxifragaceae		
Boykinia richardsonii (Hook.) Gray	Richardson boykinia	U
Chrysoplenium tetrandrum (Lund) T. Fries	Northern water carpet	U
Leptarrhena pyrolifolia (D. Don) Ser.	Leather-leaf saxifrage	U
Parnassia palustris L.	Northern Grass-of-Parnassus	U I
Parnassia kotzebuei Cham. & Schlecht.	Kotzebue Grass-of-Parnassus	U I
Parnassia sp.	Grass of Parnassus	D
Ribes hudsonianum Richards.	Northern black currant	U D
Ribes laxiflorum Pursh (may be *R. glandulosum*)	Trailing black currant	D
Ribes triste Pall.	Red currant	U D I
Saxifraga bronchialis L.	Spotted saxifrage	U
Saxifraga davurica Willd.	Saxifrage	U
Saxifraga foliolosa R. Br.	Grained saxifrage	U
Saxifraga hieracifolia Waldst. & Kit.	Stiff-stemmed saxifrage	U
Saxifraga lyallii Engler	Red-stem saxifrage	U
Saxifraga oppositifolia L.	Purple mountain saxifrage	U I
Saxifraga punctata L.	Brook saxifrage	U
Saxifraga serpyllifolia Pursh	Thyme-leaf saxifrage	U
Saxifraga tricuspidata Rottb.	Three-tooth saxifrage	U I
Scrophulariaceae		
Castilleja caudata (Pennell) Rebr.	Pale Indian paintbrush	U I
Mimulus guttatus DC.	Yellow monkey flower	I
Pedicularis capitata Adams	Capitate lousewort	U
Pedicularis kanei Durand	Kane lousewort	U I
Pedicularis labradorica Wirsing	Labrador lousewort	U I
Pedicularis parviflora J.E. Sm. var. *parviflora*	Lousewort	U
Pedicularis sudetica Willd.	Lousewort	U
Pedicularis verticillata L.	Whorled lousewort	U
Pedicularis sp.	Lousewort	I
Veronica americana	Brooklime	I
Veronica wormskjoldii Roem. & Schult.	Alpine speedwell	U I
Umbelliferae (Apiaceae)		
Angelica lucida L.	Wild celery	U
Heracleum lanatum Michx.	Cow parsnip	U D I
Valerianaceae		
Valeriana capitata Pall.	Capitate valerian	U I
Violaceae		
Viola biflora L.	Violet	I
Viola epipsila Ledeb.	Marsh violet	U I
Viola langsdorffii Fisch.	Violet	U
Viola sp.	Violet	I

Table J-6. (Continued)

Scientific Name†[1]	Common Name	Location†[2]
NONVASCULAR PLANT SPECIES		
Lichens		
Cetraria cucullata (Bell.) Ach.		U
Cetraria islandica (L.) Ach.		U
Cetraria nivalis (L.) Ach.		U
Cetraria richardsonii Hook.		U
Cetraria spp.		U
Cladonia alpestris (L.) Rabenh.		U
Cladonia mitis Sandst.		U
Cladonia rangiferina (L.) Web.	Reindeer moss	U
Cladonia spp.		U
Dactylina arctica (Hook.) Nyl.		U
Haematomma sp.		U
Lobaria linita (Ach.) Rabh.		D
Nephroma spp.		U
Peltigera spp.		U
Rhizocarpon geographicum (L.) DC.		U
Stereocaulon paschale (L.) Hoffm.		U D
Thamnolia vermicularis (Sw.) Schaer.		U
Umbilicaria sp.		U
Mosses		
Climacium sp.		U
Hypnum spp. and other feather mosses		U
Paludella squarrosa (Hedw.) Brid.†[5]		U
Polytrichum spp.		U D
Ptilium crista-castrensis (Hedw.) DeNot.	Knight's plume	U
Phacomitrium spp.		U D
Sphagnum spp.		U D

†[1] First order name = order; second order name = family, third order name = genus and species. Vascular plant species nomenclature according to Hulten (1968) except where noted. Lichen nomenclature according to Thomson (1979). Moss nomenclature according to Conard (1979).

†[2] U = upper and middle Susitna Basin; D = downstream floodplain; I = Healy-to-Willow transmission corridor study area.

†[3] Nomenclature according to Welsh (1974).

†[4] Nomenclature according to Viereck and Little (1972).

†[5] Nomenclature according to Crum (1976).

Source: Modified from Exhibit E, Vol. 6A, Chap. 3, Appendix 3.C, as adapted from McKendrick et al. (1982), Commonwealth Associates (1982), and Steigers et al. (1983).

The proposed sites of the dams, impoundments, and related project facilities would be located mostly in forested areas (Fig. J-2). In the vicinity of the proposed Watana dam site and impoundment (Fig. J-2), more than 75% of the vegetated area is forested, and most of the remaining area is shrubland (both low-shrub and tall-shrub types). The predominant forest types are woodland and open black spruce and open mixed conifer-deciduous forest. The area around the proposed construction camp, village, and airstrip sites (Fig. J-2) is covered by low-shrub types. The borrow sites (Figs. 2-2 and 2-6) would be located in areas covered predominantly by various forest types and shrubland, primarily low-shrub types. Borrow sites A, E, H, and I are mostly forested; whereas sites D and F are mostly low shrubland. Borrow site A also includes a relatively large area of mat and cushion tundra, and borrow site D includes a small area of wet sedge-grass tundra.

Almost all of the area occupied by the proposed Devil Canyon dam site and impoundment (Fig. J-2) is forested, and almost 50% of the forests are mixed conifer-deciduous types. Other significant forest types found in the area include closed birch, open and woodland black spruce, and open white spruce. The sites of the proposed construction camp and village (Fig. J-2) and over 75% of proposed borrow site K (Fig. 2-6) would be located in closed mixed conifer-deciduous forest. Proposed borrow site G (Fig. 2-6) is relatively small and has stands of woodland and open black spruce, closed mixed conifer-deciduous forest, and open tall shrub.

The proposed access routes (Fig. 2-11) because of their lengths and varied elevations, would cross a variety of vegetation types. The proposed Denali Highway-to-Watana access route would cross mostly low shrubland, as well as smaller areas of mat and cushion tundra and both mesic and wet sedge-grass tundra types. The tundra types generally occur at the higher elevations. The proposed Watana-to-Devil Canyon access route would traverse mostly shrublands (both low shrub and tall shrub) and various tundra types, but it also would cross forested areas (mostly mixed conifer-deciduous and woodland and open white spruce) near Tsusena Creek and the Susitna River. From Devil Canyon to Gold Creek, closed mixed conifer-deciduous forest is the predominant vegetation type that would be crossed by the proposed rail access. The proposed Dams-to-Gold Creek power transmission corridor (Fig. 2-7) would follow a route similar to that of the proposed Watana/Devil Canyon/Gold Creek access routes and, thus, would cross similar vegetation types.

The areas covered by the vegetation types illustrated in the 1:250,000-scale maps (Exhibit E, Vol. 6B, Chap. 3, Fig. E.3.38) are given in Table J-7. The vegetation types covering the largest areas are mixed low shrub (29% of the total area), woodland spruce forest (12%), and mesic sedge-grass tundra (11%). However, with the relatively small scale (1:250,000) of this map, the smallest practical mappable unit is 640 acres (260 ha). Thus, the level of detail associated with Figure E.3.38 in Exhibit E (Vol. 6B, Chap. 3) and Table J-7 is quite low.

The larger scale (1:63,360) maps (Fig. J-2) provide greater resolution [smallest practical mappable unit is 40 acres (16 ha)], but they cover a smaller area that is limited to 10 mi (16 km) on either side of the Susitna River between Gold Creek and the Tyone River. The areas covered by vegetation types shown on the larger scale maps are listed in Table J-8. Shrubland and tundra formations cover similar percentages of the 20-mi (16-km) wide area as they do in the entire upper and middle Susitna Basin (Table J-7), but the percentage of forested areas along the river is greater because the slopes along the river make up a larger portion of the total area in the 1:63,360 maps. Because of their greater detail, the 1:63,360-scale maps were used to calculate areas of various vegetation types that would be impacted by the proposed project (Sec. J.2.1).

Each of the vegetation types identified in Table J-8 was sampled and described by McKendrick et al. (1982). Plant cover by species within vertical stratification layers for each vegetation type is presented in Exhibit E (Vol. 6B, Chap. 3, Tables E.3.53 - E.3.63 and E.3.65 - E.3.69). Criteria used to assign individual plants to vertical layers are summarized in Table J-9. Brief descriptions (adapted from McKendrick et al., 1982) of each vegetation type follow.

J.1.2.1.1 Forests

The occurrences of various forest types in the upper and middle Susitna Basin often can be related to such factors as elevation, slope, aspect, drainage, and fire history. In the taiga ecosystems (moist subarctic forests) of Interior Alaska, these factors apparently influence ecosystem structure and function through effects on air and soil temperatures, soil moisture, and the presence of permafrost (Van Cleve and Viereck, 1981; Van Cleve et al., 1983).

In general, black spruce forests are most common throughout the taiga, and they are usually found on poorly drained sites, including those underlain by permafrost and those on north-facing slopes. Conversely, upland white spruce forests usually occur on warmer, well-drained sites. Deciduous forests of paper birch, trembling aspen, or mixed birch-aspen and mixed deciduous-white spruce forests are considered successional stages leading to white spruce. Bottomland spruce and balsam poplar forests occur along rivers, and the successional stages leading to these forest types, including shrubs and balsam poplar stands, are discussed in Section J.1.2.2.

Table J-7. Acreage and Percentage of Total Area Covered by Vegetation Types in the Upper and Middle Susitna Basin†[1]

Vegetation Type	Acres†[2]	Percentage of Total Area†[2]
Total vegetation	3,429,000	85.1
Forest	860,000	21.3
Conifer	760,000	18.9
Woodland spruce	466,000	11.6
Open spruce	294,000	7.3
Closed spruce	1,000	0.02
Deciduous	3,000	0.07
Open birch	2,000	0.05
Closed birch	1,000	0.02
Mixed conifer-deciduous	97,000	2.4
Open	58,000	1.4
Closed	39,000	1.0
Tundra	975,000	24.2
Wet sedge-grass	12,000	0.3
Mesic sedge-grass	456,000	11.3
Mat and cushion	161,000	4.0
Mat and cushion/sedge-grass	345,000	8.6
Alpine herbaceous	2,000	0.05
Shrubland	1,593,000	39.5
Tall shrub	319,000	7.9
Low shrub	1,274,000	31.6
Birch	83,000	2.1
Willow	26,000	0.6
Mixed	1,165,000	28.9
Unvegetated	601,000	14.9
Water	98,000	2.4
Lakes	62,000	1.5
Rivers	36,000	0.9
Rock	281,000	7.0
Snow and ice	222,000	5.5
Total area	4,030,000	100

†[1] Based on maps produced at a scale of 1:250,000. Differences in resolution as a result of differences in scale may result in some discrepancies for common areas between these values and those presented in Table J-8.

†[2] Acreages and percentages do not add up to totals for each major vegetation type due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Exhibit E, Vol. 6B, Chap. 3, Table E.3.51, by conversion to the nearest 1000 acres from hectares (originally based on McKendrick et al., 1982).

Table J-8. Acreage and Percentage of Total Area Covered by Vegetation Types for the Area Ten Miles (16 km) on Either Side of the Susitna River from Gold Creek to the Tyone River†[1]

Vegetation Type	Acres†[2]	Percentage of Total Area†[2]
Forest	352,000	30.8
Conifer	284,000	24.8
Woodland spruce-black	156,000	13.6
Woodland spruce-white	33,000	2.9
Open spruce-black	70,000	6.1
Open spruce-white	26,000	2.3
Deciduous	11,000	1.0
Open birch	4,000	0.3
Closed birch	6,000	0.5
Closed balsam poplar	1,000	0.1
Mixed conifer-deciduous	56,000	4.9
Open	24,000	2.1
Closed	33,000	2.9
Tundra	283,000	24.8
Wet sedge-grass	9,000	0.8
Mesic sedge-grass	68,000	5.9
Mat and cushion	157,000	13.7
Sedge/shrub	50,000	4.4
Shrubland	438,000	38.3
Tall shrub	77,000	6.7
Open	38,000	3.3
Closed	39,000	3.4
Low shrub	361,000	31.6
Birch	106,000	9.3
Willow	20,000	1.7
Mixed	234,000	20.5
Herbaceous	<100	<0.1
Grassland	3,000	0.3
Disturbed	<100	<0.1
Unvegetated	67,000	5.9
Water	25,000	2.2
Rivers	10,000	0.9
Lakes	15,000	1.3
Rock	41,000	3.6
Snow and ice	1,000	0.1
Total Area	1,143,000	100

†[1] Based on maps produced at a scale of 1:63,360. Differences in resolution as a result of differences in map scale may result in some discrepancies for common areas between these values and those presented in Table J-7.

†[2] Acreages and percentages do not add up to totals for each major vegetation type due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Exhibit E, Vol. 6B, Chap. 3, Table E.3.52, by conversion to the nearest 1000 acres from hectares (originally based on McKendrick et al., 1982).

Table J-9. Criteria for Assignment of Individual Plants to Vertical Layers in the Plant Community for Purposes of Stratified Canopy Cover Measurements

Vertical Layer	Criteria
Ground layer	All herbaceous and woody species < 1.6 ft tall
Shrub layer	Woody species > 1.6 ft tall and < 1 in dbh†[1]
Understory	Woody species > 1 in dbh and < 4 in dbh
Overstory	Woody species > 4 in dbh

†[1] dbh = diameter at breast height.

Conversions: To convert feet to meters, multiply by 0.305.
To convert inches to centimeters, multiply by 2.54.

Source: Based on McKendrick et al. (1982).

In the upland areas of the taiga, fire recurs in some forest types as often as every 30 to 100 years (Yarie, 1981). It is a common phenomenon and a major factor affecting the distribution of upland vegetation types; an average of from 0.6% to 1% of the forested land in Interior Alaska has burned annually since records have been kept, starting in 1940 (Van Cleve et al., 1983). Due to the recurrent fires, mature forest stands more than 200 years old are rare, except perhaps in the floodplains. The fires are often patchy, resulting in a mixture of various-aged vegetation stands that are superimposed over variations in slope and aspect, thus creating a mosaic of vegetation types (Van Cleve et al., 1983). The speed and direction of revegetation following a fire is relatively complex and depends on such factors as: preburn vegetation type and age, soil type and moisture content, weather conditions, climate, time of the burn, and fire severity (depth of organic layer removed). The depth of burn is very important because many species (including paper birch, trembling aspen, prickly rose, Labrador tea, blueberry, cranberry, and bluejoint) regenerate from underground parts located primarily in the organic layer, and may be killed if that layer is burned very deeply. However, exposed mineral soils provide the best locations for seed germination of species--such as black spruce, willow, and fireweed--that are adapted to reinvasion of burned areas by seed. Horsetails and species of the moss Polytrichum have rhizomes and rhizoids that grow into the mineral soil, allowing these plants to regenerate by vegetative means following all but the most severe fires (Viereck and Schandelmeier, 1980; Viereck, 1983).

Even though there is potentially great variability in the sequences of revegetation following fire in the forests and shrublands of Interior Alaska, two general sequences that are pertinent to the proposed project area have been described (Viereck and Schandelmeier, 1980; Van Cleve and Viereck, 1981). One occurs on relatively cold, wet, poorly drained, permafrost sites dominated by black spruce. The other sequence occurs on more productive, mesic sites in which shrub and hardwood stages often lead to mature white spruce stands.

Following fire on relatively cold, poorly drained sites, the initial vegetation stage consists of herbs and tree and shrub seedlings and is followed by a stage in which shrubs, such as willow or alder, dominate. About 25 to 50 years after the fire, black spruce saplings begin to dominate, and the mature black spruce-moss community type develops after 100 to 200 years, if fire does not recur. In the early years following a fire, the reduced thickness of the soil organic layer and changes in surface albedo result in warmer soil temperatures and deepening of the active layer (annual thaw depth) of permafrost areas. These changes, along with increased nutrient availability (except in cases of significant erosion), are probably the major factors causing observed increases in the productivity of black spruce areas following a fire. However, as the insulating organic layer accumulates over the years during succession, the active layer becomes shallower, nutrient availability is reduced, and productivity is lowered (Van Cleve and Viereck, 1981; Van Cleve et al. 1983).

On warmer, drier sites, the initial herb and seedling stage and the subsequent shrub stage are followed 25 to 50 years after the fire by a dense hardwood stage that is dominated by paper birch and trembling aspen. As the hardwoods mature, white spruce develops. If fire does not recur, the mixed white spruce-hardwood stage occurs after 100 to 200 years, and eventually the hardwoods die out, leaving the mature white spruce-moss community type. Permafrost is usually not present on such sites. Compared with black spruce successional types, decomposition rates are higher, the organic layer accumulates much more slowly, and productivity is generally higher (Van Cleve and Viereck, 1981; Van Cleve et al. 1983). Successional changes in vegetation and corresponding changes in the thicknesses of the organic layer and active layer for black and white spruce types are illustrated in Figure J-3.

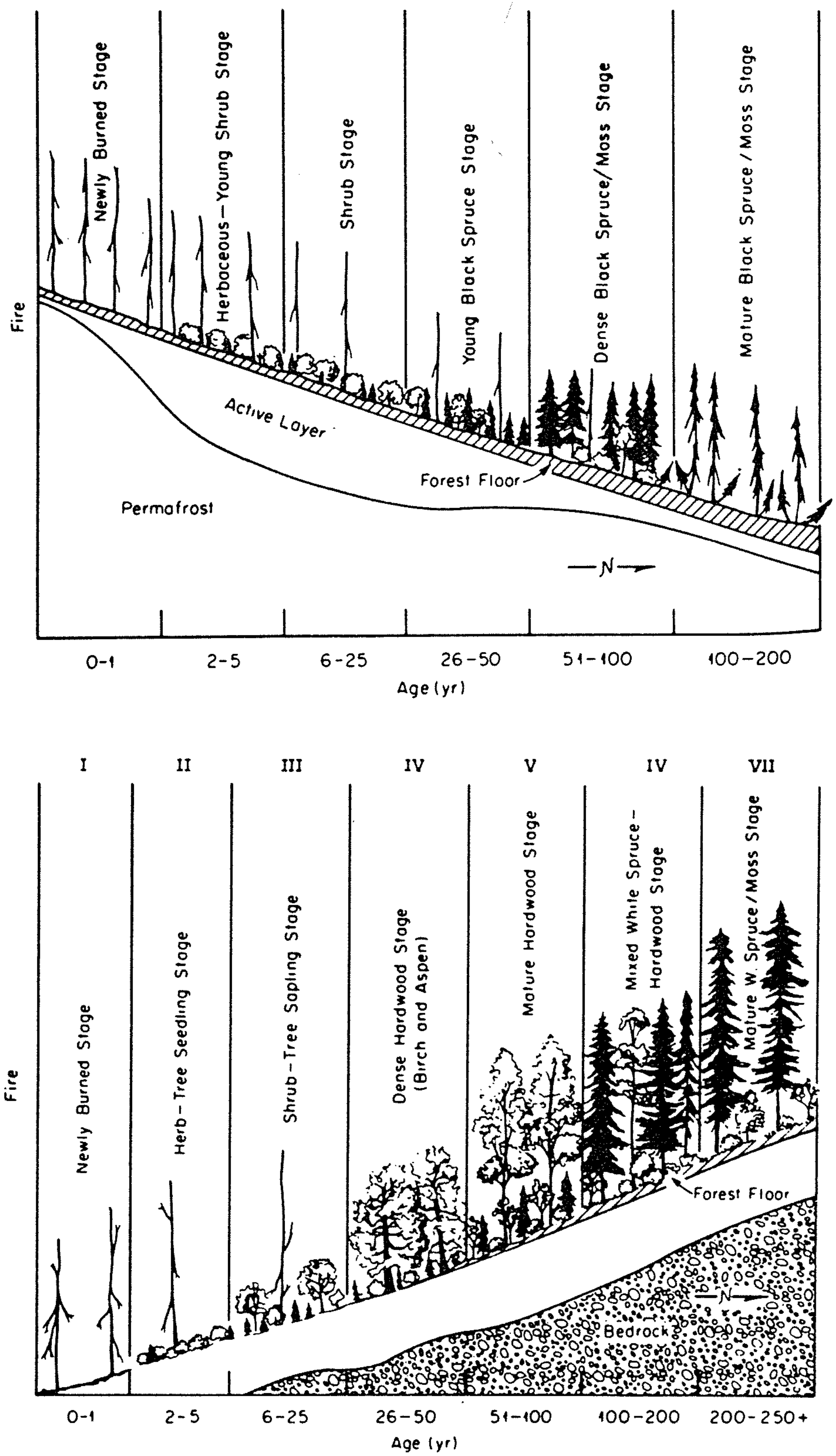


Figure J-3. Upland Successional Sequence Following Fire in (Top) Black Spruce and (Bottom) White Spruce. [Source: Van Cleve and Viereck, 1981: Figs. 3.2 and 3.3. Copyrighted 1981 Springer-Verlag New York. Used with permission of the publisher.]

In contrast, succession in the floodplain is controlled primarily by river action since these areas are relatively protected from fire except on the older terraces (Van Cleve and Viereck, 1981). A typical floodplain successional sequence is described in Section J.1.2.2.

In the upper and middle Susitna Basin, forest types occur at the lower elevations and cover 21% of the total area and 31% of the 20-mi (32-km) wide area along the Susitna River. The mean elevation of forest stands sampled by McKendrick et al. (1982) was 1,716 ft (523 m) MSL, and the elevational range was 1,100 to 2,600 ft (340 to 790 m) MSL. McKendrick et al. (1982) reported that in general for the upper and middle Susitna Basin, black spruce did occur on wetter sites than white spruce, whereas deciduous or mixed forests occurred on the warmer sites. Closed forests were also found on warmer sites. Furthermore, in areas of closed forest, drier sites usually supported deciduous stands, whereas moister sites had mixed forests or were dominated by spruce.

CONIFEROUS FORESTS

The coniferous forests in the upper and middle Susitna Basin are dominated either by black or white spruce. Although one closed conifer area (located in the Lake Louise area) was mapped by McKendrick et al. (1982), only open and woodland spruce types were actually sampled. The attributes of open black and white spruce forest types are compared in Table J-10.

Table J-10. Comparison of Characteristics of Black Spruce Forests and White Spruce Forests

Attribute	Black Spruce	White Spruce
Canopy area of spruce trees	Smaller	Larger
Maximum height (ft)	16 to 36	Up to 66
Vertical stratification	Occurrence of dominant relatively equal in all layers, highest in shrub layer	Occurrence of dominant mostly in overstory
Age of sampled spruce trees (yrs)	77-171	34-78

Conversion: To convert feet to meters, multiply by 0.305.

Source: Based on McKendrick et al. (1982).

Both open black and white spruce stands possess a well-developed ground layer that accounts for most of the vegetation cover. Open black spruce stands contain low shrubs--including crowberry, northern Labrador tea, bog blueberry, and mountain cranberry--in the ground layer and some white spruce in the understory and overstory. In open white spruce stands, Sitka alder and American green alder are present in the understory and shrub layers. The ground layer is dominated by more herbaceous species, including bluejoint and twinflower, than in black spruce stands. Low shrubs occurring in the ground layer are also different from those found in the black spruce stands; they include prickly rose and resin birch. Mosses, especially feather mosses, are prevalent (~ 30% cover) in both black and white spruce stands.

Open spruce stands, located primarily on riverine slopes and terraces, cover about 7% of the total upper and middle Susitna Basin. The mean elevation of the open spruce stands sampled by McKendrick et al. (1982) was 1,600 ft (488 m) MSL, with a range of 1,100 to 1,950 ft (340 to 590 m). Woodland spruce stands were usually found on relatively level benches with poorly drained soils at a mean elevation for the stands sampled by McKendrick et al. (1982) of 2,046 ft (624 m) MSL. The elevational range of the sampled woodland spruce stands was 1,600 to 2,600 ft (490 to 790 m) MSL.

Woodland spruce is the most widespread forest type in the upper and middle Susitna Basin, covering about 12% of the total area. All woodland spruce stands sampled by McKendrick et al. (1982) were black spruce. Woodland spruce stands are composed of scattered, stunted trees that are often too small to qualify for the overstory layer because trunks are less than 4 in (10 cm) diameter at breast height (dbh). In some areas, maximum heights are less than 7 ft (2 m). In woodland spruce, sphagnum mosses replace feather mosses as the dominant ground-layer species. Other ground-layer species are similar to those in open black spruce stands except for the addition of various sedge species. Woodland spruce areas often grade into boggy areas or are difficult to distinguish from low birch shrub types (McKendrick et al., 1982).

DECIDUOUS FORESTS

Deciduous forests are restricted almost entirely to the steep banks and floodplain along the river. They cover less than 0.1% of the entire upper and middle Susitna Basin and only 1% of the 20-mi (32-km) wide area along the Susitna River. Average elevation of stands sampled by McKendrick et al. (1982) was 1,910 ft (583 m) MSL [range = 1,400 to 2,100 ft (430 to 640 m) MSL], with closed stands occurring at generally lower elevations than open stands. The forest canopy of each stand is generally dominated by only one of three species: paper birch, trembling aspen, or balsam poplar. Vegetation cover is nearly complete, with a well-developed ground layer. Open stands tend to have more woody cover in the ground layer, whereas closed stands have a greater component of herbaceous species.

Paper birch stands occur on steep, usually south-facing slopes that often have been recently subjected to disturbance. These were the only deciduous stands large enough to map at the 1:250,000 scale. Closed balsam poplar stands generally are found on islands in the river or on flat areas in the floodplain, since this species is usually the first tree to become established during successional development of alluvial deposits (see Sec. J.1.2.2). Balsam poplar stands were large enough to map at the 1:63,360 scale. The trembling aspen stands were not mappable even at the 1:24,000 scale. These small stands are infrequently found at the upper levels of dry, south-facing slopes. Van Cleve and Viereck (1981) indicated that aspen stands are usually found on warmer and drier sites than are birch, poplar, or spruce stands.

MIXED CONIFER-DECIDUOUS FORESTS

The mixed conifer-deciduous forests of the upper and middle Susitna Basin are commonly dominated by white spruce and hardwoods, primarily paper birch. They are typical of the Interior Alaska mixed forest type described by Van Cleve and Viereck (1981). This vegetation type is believed to be a successional stage in which white spruce is replacing deciduous forest. This vegetation type accounts for about 2% of the total area in the upper and middle Susitna Basin and almost 5% of the area within 10 mi (16 km) on either side of the Susitna River. Most of the larger stands are found on slopes along the river on the western end of the middle Susitna Basin (downstream of Tsusena Creek). The mean elevation of the stands sampled by McKendrick et al. (1982) was 1,530 ft (467 m) MSL, with a range of 1,200 to 2,250 ft (370 to 690 m) MSL. Closed stands are generally found at lower elevations than open stands. Overstory cover is intermediate between that of conifer and deciduous forests. Total cover is almost complete, with a well-developed ground layer. In open stands the shrub layer is also important. Many of the stands sampled by McKendrick et al. (1982) had trees more than 100 years old.

J.1.2.1.2 Shrublands

Shrublands are the most commonly occurring vegetation type in the upper and middle Susitna Basin, covering almost 40% of the area. In general, shrublands are found at mid-elevations, above forest communities but below tundra systems. However, as a result of fires, shrub types are also found mixed with forest stands. Two major types are present: tall and low shrub. Of all types, however, mixed (birch-willow) low shrub is by far the most prevalent.

Tall shrub types are dominated by alder, primarily Sitka alder and, secondarily, American green alder. These stands are often 7 to 13 ft (2 to 4 m) in height. Closed alder stands have almost complete cover, with the ground layer and understory contributing the most cover. Portions of some closed stands are actually thickets. Open alder stands are similar in composition to closed stands, but have less cover. Bluejoint and woodland horsetail are important ground-layer species.

Tall shrub stands occur mostly on steep slopes above the Susitna River, often in narrow strips through other vegetation types. They also occur in strips along tributary drainages and in rings around mountains at certain elevations. Mean elevation of the stands sampled by McKendrick et al. (1982) was 1,880 ft (573 m) MSL [range = 1,600 to 2,550 ft (490 to 780 m) MSL].

Low shrub types are dominated by birch, willow, or a mixture thereof. Birch stands are usually dominated by resin birch, but other low shrubs are often present, especially northern Labrador tea and bog blueberry. Some stands are dense and thicket-like, whereas in other stands individual shrubs are separated by large openings. Some stands contain scattered black spruce, which makes these stands difficult to separate from woodland spruce types.

Willow stands generally occur on wetter areas than birch stands and are dominated by diamondleaf willow. Due to the wetness (often including standing water), willow stands are usually less diverse than birch stands. Water sedge is an important herbaceous species in willow stands.

Low shrub types are located primarily on the extensive, relatively flat benches above the Susitna River Valley, are most often associated with soils that are frequently wet and gleyed, but are usually without standing water, except for willow types. Willow types often occur as thickets along small streams at high elevations. The mean elevation of the low shrub stands sampled by McKendrick et al. (1982) was 2,562 ft (781 m) MSL [range = 2,100 to 3,200 ft (640 to 980 m) MSL].

J.1.2.1.3 Tundra

Tundra communities usually occur above the tree line and cover about 24% of the area within the upper and middle Susitna Basin. Well-vegetated communities are found mostly on flat to gently sloping areas, whereas communities occurring on steep or rocky terrain are more sparsely vegetated. Although the species composition of tundra areas is highly variable (about 70 vascular plant species were identified by McKendrick et al., 1982), four distinct types were found in areas large enough to map. These types were wet sedge-grass tundra, mesic sedge-grass tundra, alpine herbaceous tundra, and closed mat and cushion tundra. Means and ranges of elevations for each of the four types are listed in Table J-11.

Table J-11. Elevations of Tundra Areas Sampled in the Upper and Middle Susitna Basin

	Elevation (ft MSL)	
Tundra Type	Mean	Range
Wet sedge-grass	1,926	1,400 - 2,550
Mesic sedge-grass	4,502	NA†[1]
Mat and cushion	3,280	2,600 - 4,000
Alpine herbaceous (herb-sedge)	4,249	NA

†[1] NA = Not available.

Conversion: To convert feet to meters, multiply by 0.305.

Source: Based on McKendrick et al. (1982).

Wet sedge-grass tundra is more common below the tree line than the other tundra types, occurring in wet, depressed areas with poor drainage. Vegetation cover is almost complete. The most important ground-layer species are water sedge, Bigelow sedge, bluejoint, and sphagnum mosses. A shrub layer of scattered willows is present in some stands. The organic matter content of soils is usually high and sometimes is present as a thick organic layer over the mineral soil.

Mesic sedge-grass tundra usually occurs on rolling uplands with well-drained soils. Vegetation cover is 50% to 70% in these stands, with Bigelow sedge predominant. Vegetation is confined to the ground layer, and is usually less than 1 ft (30 cm) tall. Soils are well-developed in some areas but patchy in others.

Mat and cushion tundra occurs on dry, windy ridges. Vegetation cover is about 75%. All vegetation is in the ground layer, and is usually less than 8 to 12 in (20 to 30 cm) tall. Dominant species are lichens and low mat-forming shrubs, such as dwarf arctic birch, crowberry, bearberry, bog blueberry, and northern Labrador tea. Soils are shallow and coarse.

Two types of alpine herbaceous tundra are present in the upper and middle Susitna Basin, although only one, herb-sedge, is present in areas large enough to map. Herb-sedge communities occur at high elevations near glaciated areas on gentle, well-drained slopes with relatively well-developed soils. Vegetation cover is almost complete but limited to the ground layer. Species composition is very diverse, and no species groups dominate the community type. Soils are essentially mineral soils with about 5% organic matter. The other alpine herbaceous tundra type occurs in small, isolated rocky areas. Small pioneering forbs, and sometimes shrubs, occur in pockets of mineral soil imbedded between rocks.

The natural fire regime in the tundra is not well understood. There is little information on the frequency of natural fires in the tundra, but there is some evidence that they are far less frequent and generally cover much smaller areas than in the taiga (Viereck and Schandelmeier, 1980). Generally, the results of tundra fires are extremely variable, but in most cases, the vegetation is rarely destroyed completely by the fire. Recovery usually is by vegetative means and occurs rapidly, often with all signs of the fire disappearing within six to eight years. Usually the most important effects of the fire are increases in the depth of the active layer and in the flowering of many species, especially the sedges. Dwarf shrub species often respond more slowly than the sedges and grasses, and areas with abundant lichens may take more than 20 years to fully recover. If the organic layer is burned to the mineral soil, fireweed and other forbs may invade (Viereck and Schandelmeier, 1980).

J.1.2.1.4 Other Vegetation Types and Unvegetated Areas

Two herbaceous vegetation types are present in the upper and middle Susitna Basin. One type consists of herbaceous pioneer species that invade gravel and sand bars on the river during early successional stages (see Sec. J.1.2.2). Pioneer species include horsetails, lupines, and alpine sweetvetch. The other type is grassland dominated by bluejoint. These communities are found on level to sloping areas at lower elevations along the Susitna River and the Portage Creek drainage.

Unvegetated areas consist of water, rock, snow, and ice. These areas comprise 15% of the upper and middle Susitna Basin. Water areas consist of lakes and streams. Lakes are generally found on flat benches. Rock areas include bedrock or deposited geologic materials that support little or no vegetation. Rock areas are usually found as unconsolidated gravel in newly deposited river bars or as outcrops either along the Susitna River or at high elevations. Snow and ice areas comprise permanent snowfalls and glaciers in the Alaska Range and to some extent in the Talkeetna Mountains.

J.1.2.1.5 Wetlands

Within the upper and middle Susitna Basin, wetlands include riparian zones, ponds and lakes on upland plateaus, and areas with wet or poorly-drained soils supporting communities such as wet sedge-grass tundra, low shrubland, or black spruce forest. Wetland areas that have been identified within the upper and middle Susitna Basin near the proposed project features include upper Brushkana and Tsusena creeks, the area between lower Deadman and Tsusena creeks, the Fog Lakes area, and the areas around Stephan Lake and Prairie Creek, Swimming Bear Lake, and Jack Long Creek (Fig. J-4). There are also large numbers of lakes in the extensive flat areas of the upper and middle Susitna Basin, such as those in the vicinity of Lake Louise (Exhibit E, Vol. 6A, Chap. 3, p. E-3-223).

McKendrick et al. (1982) surveyed vascular aquatic vegetation in and around 24 lakes and ponds within the upper and middle Susitna basin. A description of dominant species, factors which may influence species locations in and around the water bodies, total vegetation cover, and the width of surrounding wetland areas can be found in McKendrick et al. (1982) and Exhibit E (Vol. 6A, Chap. 3, pp. E-3-211 - E-3-212).

As indicated in Section J.1.2 and illustrated in Table J-5, the wetlands classifications of Cowardin et al. (1979) can be liberally correlated to the vegetation classifications of Viereck and Dyrness (1980). Of course, not all of a particular vegetation type that is correlated to a wetland classification is likely to actually be a wetland area since these correlations do not consider factors such as soil moisture or periodic ambient water conditions. For example, all low shrub areas are not likely also to be palustrine scrub-shrub, broad-leaved deciduous wetlands, although low shrub areas that are wetlands would be classified as such. Thus, any estimation of wetland areas based strictly on vegetation types is likely to be extremely liberal and only indicative of potential wetland areas. However, at present, such an estimate of potential wetlands represents the best available data. The areal extent of potential wetlands, based on correlated vegetation types, is presented in Table J-12 for the upper and middle Susitna Basin.

J.1.2.2 Lower Susitna River Floodplain

Below the proposed Devil Canyon dam site, plant communities occurring in the Susitna River floodplain constitute the vegetation most likely to be affected by the proposed project. The vegetated areas of the floodplain along the Devil Canyon-to-Talkeetna reach have been mapped at the 1:24,000 scale (Exhibit E, Vol. 6B, Chap. 3, Figs. E.3.54 - E.3.58).

Most of the vegetation communities along the Susitna River floodplain appear to be a part of the floodplain successional sequence described by Van Cleve and Viereck (1981) and illustrated in Figure J-5. Briefly, pioneer communities consisting of herbaceous and shrub species are replaced by communities dominated first by alder and then by balsam poplar. Finally, the oldest, most stable areas are covered by mixed conifer-deciduous (white spruce-birch) forest. Through physical disturbances--such as ice processes (especially during freezeup and breakup), flooding events, and bank erosion and sediment deposition during the open water period--later seral

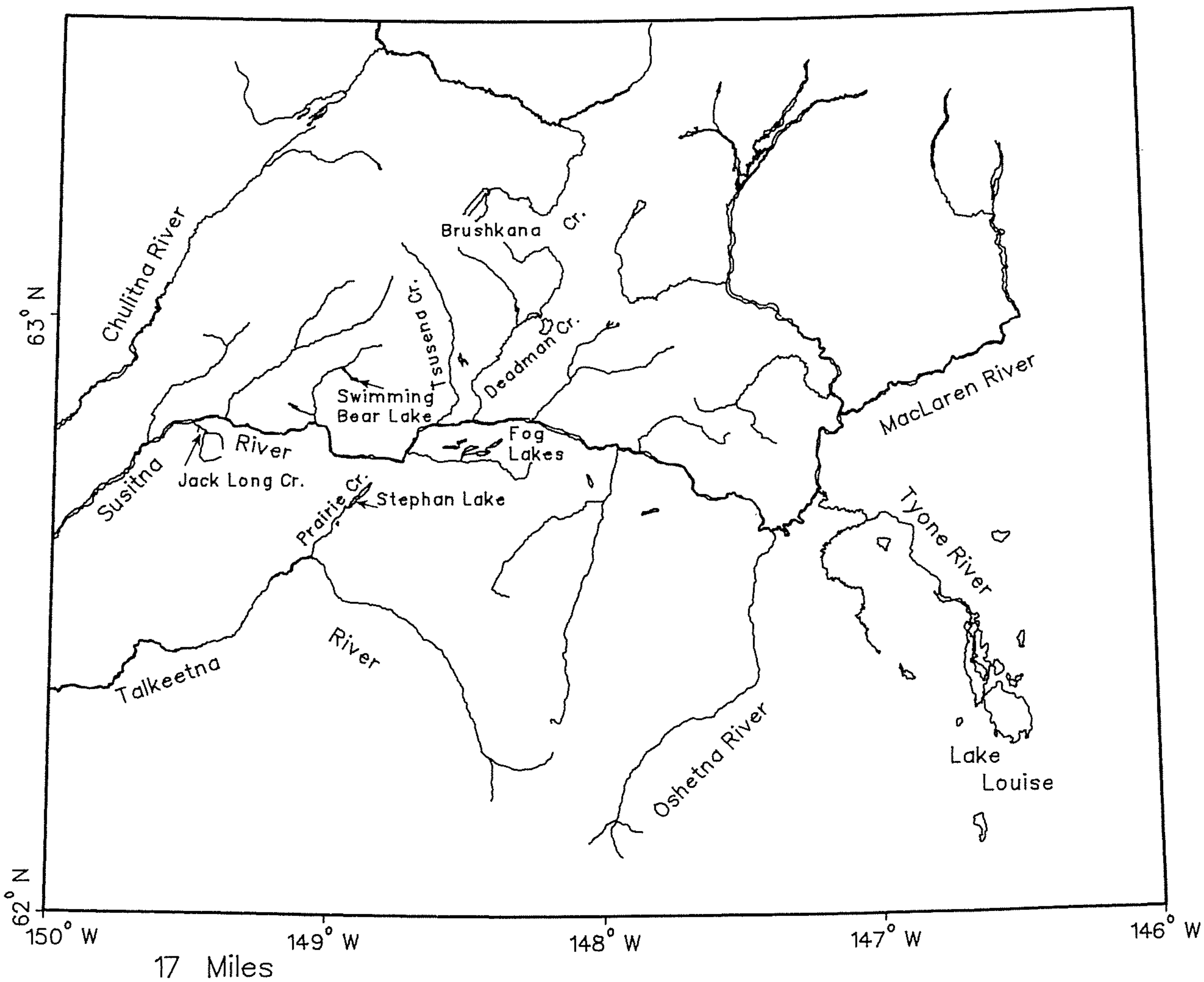


Figure J-4. Locations of Creeks and Water Bodies in the Upper and Middle Susitna Basin Around Which Wetlands Have Been Identified.

Table J-12. Estimated Areal Extent and Percentage of Total Area Covered by Potential Wetlands within the Upper and Middle Susitna Basin

Wetland Classification	Potential Area Covered (acres)†[1,2]	Percentage of Entire Upper and Middle Basin
Palustrine forested, needle-leaved evergreen	759,000	18.8
Palustrine forested, broad-leaved deciduous†[3]	1,000	<0.1
Palustrine scrub-shrub, broad-leaved deciduous	1,274,000	31.6
Palustrine or lacustrine emergent, persistent	12,000	0.3
Lacustrine	62,000	1.5
Riverine	36,000	0.9
Total Potential Wetland	2,144,000	53.2

†[1] These areas should be considered extremely liberal; see explanation in text.

†[2] Values converted from hectares as given in McKendrick et al. (1982) to acres and rounded to nearest 1000 acres.

†[3] Based on data for balsam poplar stands within 10 mi (16 km) of the Susitna River between Gold Creek and the Tyone River (Table J-8 and Exhibit E, Vol. 6B, Chap. 3, Table E.3.52).

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-7 using correlations of vegetation types to potential wetland classes as given in Table J-5.

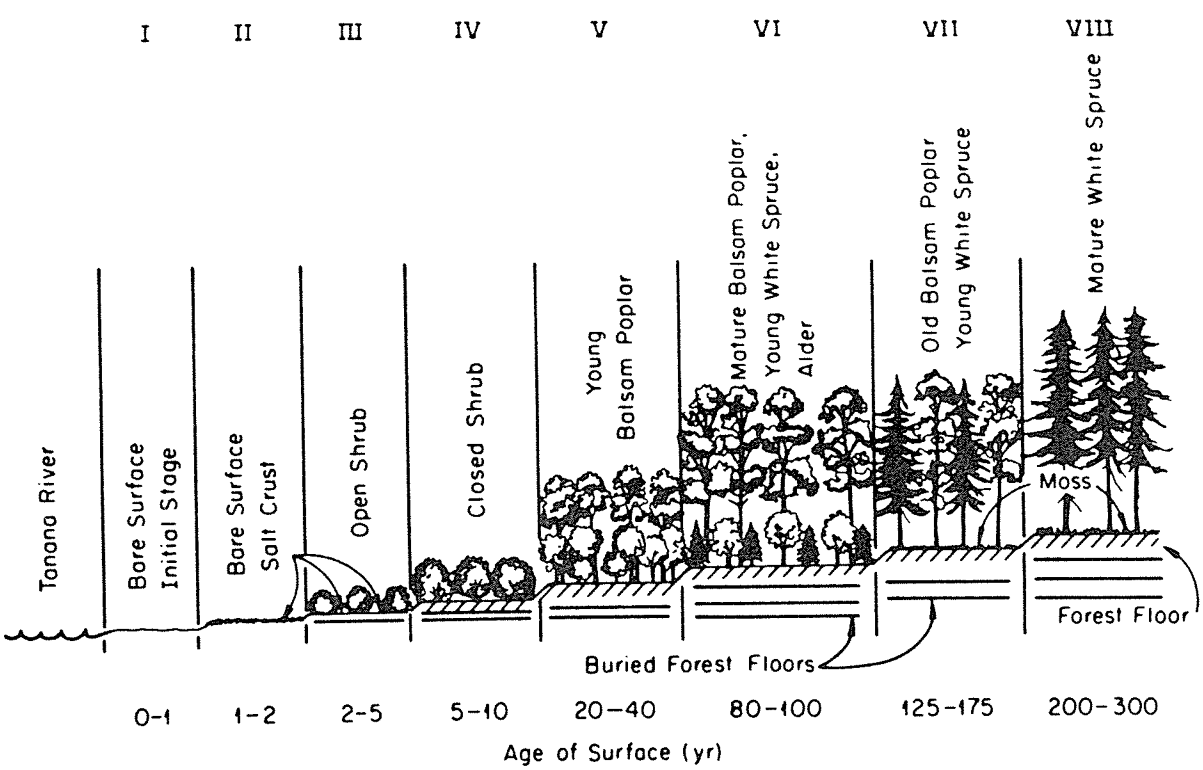


Figure J-5. Primary Succession on the Tanana River Floodplain. [Source: Van Cleve and Viereck, 1981: Fig. 3.1. Copyrighted 1981 Springer-Verlag New York. Used with permission of the publisher.]

stages may be replaced by earlier seral stages. Thus, because of physical disturbances, vegetation development in a given area may not proceed directly through the entire successional sequence illustrated in Figure J-5.

Below the Devil Canyon dam site to Talkeetna, the Susitna River valley is relatively incised. The channel is often armored with cobbles and boulders. Midchannel gravel bars are regularly reworked, but the centers of many islands are well-vegetated with later-successional stands, indicating relatively infrequent disturbance except along island perimeters (R&M Consultants, 1982). In this reach, the vegetated areas of the floodplain appear to be 5%-10% pioneer communities, 20% alder and/or immature balsam poplar, 25%-40% mature to decadent balsam poplar, and 20%-35% white spruce-birch forests (McKendrick et al., 1982).

Below Talkeetna to Cook Inlet, the Susitna River channel is braided with a broader floodplain. Gravel bars, islands, and terraces along the river are constantly being reworked by the action of the river as the river meanders through the active gravel floodplain. Erosive processes are slowed when the river flows against vegetated bank lines. However, it is generally difficult for vegetation to establish in the active floodplain because of the dynamic nature of the system and the frequency of disturbance. Bankfull floods cause major changes in the active floodplain, whereas flows of greater magnitude can flood vegetated areas, move gravel from more stable bars into the channel, and change the channel shape and network. Because of the broad floodplain below Talkeetna, ice processes generally do not cause major changes in the overall pattern of the river and vegetated areas, since several flow relief channels are often available (R&M Consultants, 1982). The Applicant did not map vegetation in the floodplain below Talkeetna, but it is expected that the vegetation communities generally represent various stages of the floodplain successional sequence described above, except in the delta areas near the Susitna River mouth where large areas of wet sedge-grass occur (Selkregg, 1974).

Early-, mid-, and late-successional stands in the lower Susitna floodplain are briefly described in the following subsections. Plant cover by species for representative stands from each successional stage is presented in Exhibit E (Vol. 6B, Chap. 3, Tables E.3.73 - E.3.76). More detailed information concerning the density and various characteristics (e.g., height, age) of woody species is presented in McKendrick et al. (1982).

J.1.2.2.1 Early-Successional Stands

Early successional plant communities are dominated by horsetail, horsetail-willow, horsetail-balsam poplar, or dryas associations. Vegetation cover is sparse, with greater than 50% bare ground. Plant species are typically perennials that possess rhizomes. These underground stems allow vegetative reproduction and can extend laterally for many yards, effectively binding loose sand and silt.

Generally, horsetail becomes established first, except on rocky or gravelly sites where dryas appears to be more important. Woody species include balsam poplar, several willow species, and two alder species (Sitka alder and thinleaf alder). Balsam poplar densities are generally the highest, although alder grows rapidly, overtopping the other woody species within two or three years after it becomes established.

Early successional communities apparently last for up to ten years or more after the last major disturbance. Frequently, flooding will bury the vegetation in silt, but not destroy it. Then the plants often resurface and continue to grow. Such a cycle may be repeated several times before the community advances to the next seral stage.

J.1.2.2.2 Mid-Successional Stands

Mid-successional communities are dominated by either thinleaf alder or immature balsam poplar in the tall shrub or tree stage. The transition to these mid-successional stands apparently requires enough deposition of sand and silt to raise the site elevation above the level of frequent flooding.

The alder vegetation type (which corresponds to the tall shrub classification of Viereck and Dyrness, 1980) generally occurs from 10 to 25 years after stabilization, whereas the balsam poplar stage appears to dominate from 25 to 55 years after stabilization. The latter type is found less frequently than the alder stage in the floodplain of the lower Susitna River. During the transition from early- to mid-successional stages, alder overtops the shade-intolerant balsam poplar. Alder density greatly increases, while balsam poplar density greatly declines. Alder dominates for 15 to 20 years, by which time balsam poplar has reached the top of the alder canopy. Then the balsam poplar quickly doubles in height, shading the alder and developing into the immature balsam poplar stage.

In contrast to the early-successional stands, there is essentially no bare ground in the mid-successional stands. Litter and bluejoint account for most of the ground layer cover. Willow density decreases, but the densities of prickly rose and highbush cranberry increase. A few white spruce and paper birch become established during the mid-successional stage.

J.1.2.2.3 Late-Successional Stands

The balsam poplar stands probably achieve maturity about 75 years after stabilization and persist for another 30 years or more. The balsam poplar eventually becomes decadent, creating space for younger balsam poplars or for white spruce or birch.

When no further disturbance interrupts the process, white spruce-birch (mixed conifer-deciduous) forests become established on the oldest, most stable sites. It is not clear why, but some areas remain in the balsam poplar type while others change to the white spruce-birch forests. McKendrick et al. (1982) indicated there is some evidence that the white spruce-birch forests are self-perpetuating.

J.1.2.2.4 Wetlands

As indicated in Section J.1.2, the wetland classifications of Cowardin et al. (1979) can be liberally correlated to the vegetation classifications of Viereck and Dyrness (1980). Many, if not all, of the vegetated areas dominated by alder and willow in the immediate floodplain of the lower Susitna River can probably be classified as palustrine forested or scrub-shrub wetlands depending on plant height. Herbaceous pioneer communities can probably also be considered wetlands, whereas communities dominated by white spruce-paper birch are generally not likely to be wetlands.

J.1.2.3 Power Transmission Corridor

Vegetation studies along the proposed route of the transmission corridor between Fairbanks and Anchorage (Fig. 2-7) are complicated by the use of two different vegetation classification systems and different mapping scales. For the Healy-to-Fairbanks and the Willow-to-Anchorage segments, vegetation studies and mapping (at a scale of 1:63,360) were carried out by McKendrick et al. (1982) within 5-mi (8-km) wide transmission corridor study areas that encompass the actual proposed rights-of-way (Exhibit E, Vol. 6B, Chap. 3, Figs. E.3.48 - E.3.52). For the Healy-to-Willow segment, vegetation mapping (at a scale of 1:250,000) was carried out by Commonwealth Associates (1982) within a transmission corridor study area of variable width [ranging from about 4 mi (6 km) to 18 mi (29 km) wide]. The areas and distributions of vegetation types within the transmission corridor study areas are discussed below for each segment. With the exception of the Healy-to-Willow segment, vegetation type classifications follow Viereck and Dyrness (1980) and are described in Section J.1.2.1. The vegetation type classifications used for the Healy-to-Willow segment are briefly described in Table J-1. The Dams-to-Gold Creek transmission corridor segment is discussed in Section J.1.2.1.

J.1.2.3.1 Willow-to-Anchorage Segment

The Willow-to-Anchorage transmission corridor study area covers about 95,000 acres (39,000 ha) of relatively flat terrain. The approximate areas covered by each vegetation type within the study area are quantified in Table J-13. The transmission corridor study area is 67% forested. Closed mixed conifer-deciduous forests and spruce forests are the predominant forest types. Wet sedge-grass marsh (tundra) is the other major vegetation type, covering about 24% of the study area. The wet sedge-grass areas are associated with diverse networks of ponds, lakes, and meandering streams.

Major species found in the mixed forests are white spruce, paper birch, and balsam poplar. Although paper birch is the predominant deciduous species, localized balsam poplar stands occur on the active floodplain near Willow. Most open and closed spruce forests occurring in areas dominated by mixed conifer-deciduous forests are white spruce stands, but most woodland spruce forests are dominated by black spruce. Spruce stands occurring on the edges of wet sedge-grass or low shrub areas can consist of white and/or black spruce.

J.1.2.3.2 Healy-to-Willow Segment

The vegetation type classifications used by Commonwealth Associates (1982) for mapping the Healy-to-Willow transmission corridor study area (as described in Table J-1) are different from and cannot be directly compared with those of Viereck and Dyrness (1980). Additionally, the acreages of each vegetation type presented in Table J-14 are those that would actually be crossed by the proposed transmission line corridor rather than the areas within the entire Healy-to-Willow study area. The proposed Healy-to-Willow transmission corridor covers about 4,600 acres (1,900 ha). Spruce-hardwood and spruce-poplar forests are present over about 50% of the proposed corridor, and shrublands are the second most prevalent type, covering 29% of the area that would be crossed by the corridor.

The southern two-thirds of the proposed corridor is primarily forested. White spruce-birch forests occur on the drier forested sites; whereas, white spruce-balsam poplar are the major species in forested floodplain areas. Black spruce develops primarily on poorly drained sites. The northern one-third of the proposed corridor would cross mostly open woodland, shrubland, and tundra types.

Table J-13. Acreage and Percentage of Total Area Covered by Vegetation Types within the Willow-to-Anchorage Transmission Corridor Study Area

Vegetation Type	Acres†[1]	Percentage of Total Area†[1]
Forest	64,000	67.4
Conifer	22,000	23.2
Woodland spruce	6,000	6.3
Open spruce	8,000	8.4
Closed spruce	8,000	8.4
Deciduous	10,000	10.5
Open birch	40	<0.1
Closed birch	9,000	9.5
Open balsam poplar	200	0.2
Closed balsam poplar	400	0.4
Mixed conifer-deciduous	32,000	33.7
Open	4,000	4.2
Closed	28,000	29.5
Tundra	23,000	24.2
Wet sedge-grass	23,000	24.2
Shrubland	5,000	5.3
Tall shrub (closed)	200	0.2
Low shrub (mixed)	5,000	5.3
Disturbed	1,000	1.1
Unvegetated	2,000	2.1
Water	2,000	2.1
Lakes	2,000	2.1
Total Area	95,000	100

†[1] Acreages and percentages do not add up to totals for each major vegetation type due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Exhibit E, Vol. 6B, Chap. 3, Table E.3.78 and rounded to the nearest 1000 acres or one significant figure for values less than 500 (originally based on McKendrick et al., 1982).

Table J-14. Acreage and Percentage of Total Area Covered by Vegetation Types within the Proposed Healy-to-Willow Transmission Corridor

Vegetation Type	Vegetated Area Crossed†[1,2] (acres)	Percentage of Total Area†[1,2]
Upland spruce-hardwood forest	1,100	23.9
Lowland spruce-hardwood forest	830	18.0
Bottomland spruce-poplar forest	340	7.4
Wet tundra	270	5.9
Moist tundra	220	4.8
Alpine tundra	65	1.4
Shrublands	1,300	28.3
Low brush, Muskeg bog	530	11.5
Total Vegetated Area	4,600	100

†[1] Calculated from data and maps in Commonwealth Associates (1982). The values presented here represent the additional clearing of the corridor from the 110 ft (34 m) given by Commonwealth Associates (1982) to a total width of 300 ft (91 m) from Gold Creek to Healy and 400 ft (122 m) from Gold Creek to Willow. Thus, the areas presented in this table represent areas that would occur within a 190-ft (58-m) wide corridor from Gold Creek to Healy and a 290-ft (88-m) wide corridor from Gold Creek to Willow.

†[2] Areas represented are those that would actually be crossed by the proposed transmission line corridor, rounded to two significant figures. Acreages and percentages do not add up to totals due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from revisions to Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, Table E.3.79 (Revised) p. 3B-7-2, as presented in the Applicant's Responses to the Department of the Interior Comments on License Application, February 15, 1984.

J.1.2.3.3 Healy-to-Fairbanks Segment

The Healy-to-Fairbanks transmission corridor study area covers about 276,000 acres (112,000 ha). The approximate areas covered by each vegetation type within the study area are quantified in Table J-15. Forests dominate most (78%) of the transmission corridor study area and shrubland covers an additional 15%. Of the forest types, open spruce occupies the largest portion of the study area (29%). The transmission corridor study area crosses three physiographically and phytosociologically distinct sections: Healy to Nenana River, Nenana River to Tanana River, and Tanana River to Fairbanks.

From Healy to the Nenana River, a relatively flat area is bordered by a dissected plateau to the west and by the Parks Highway and Nenana River to the east. Within the transmission corridor study area, open spruce, deciduous, or mixed forests occur along the ridges leading from the plateau. Low shrubland mixed with mesic sedge-grass and both open and closed spruce stands consisting of relatively short trees dominate the flat area.

The Tanana Flats area between the Nenana and Tanana rivers is characterized by a complicated mosaic of wet vegetation types, notably open spruce [usually with larch (Larix laricina)], low shrub, and wet sedge-grass tundra. Some patches of deciduous forest are also present. McKendrick et al. (1982) found that in some parts of this area, vegetation types within the study area were too intermingled to separate in the mapping. Thus, various complexes were recognized by McKendrick and coworkers (Table J-15). The locations of many vegetation types appear to be related to old stream meanders and drainage patterns. Unlike spruce forests in the

Table J-15. Acreage and Percentage of Total Area Covered by Vegetation Types within the Healy-to-Fairbanks Transmission Corridor Study Area

Vegetation Type†[1]	Acres†[2]	Percentage of Total Area†[2]
Forest	215,000	77.9
Conifer	86,000	31.2
Woodland spruce	4,000	1.4
Open spruce	78,000	28.3
Closed spruce	3,000	1.1
Deciduous	59,000	21.4
Woodland	2,000	0.7
Open	31,000	11.2
Closed	26,000	9.4
Mixed conifer-deciduous	43,000	15.6
Woodland	2,000	0.7
Open	31,000	11.2
Closed	10,000	3.6
Complexes	26,000	9.4
Open spruce/open deciduous	2,000	0.7
Open spruce/wet sedge-grass/open deciduous	5,000	1.8
Open spruce/low shrub/wet sedge-grass/open deciduous	17,000	6.2
Open spruce/low shrub	1,000	0.4
Tundra	11,000	4.0
Wet sedge-grass	6,000	2.2
Mesic sedge-grass	1,000	0.4
Sedge/shrub	1,000	0.4
Mat and cushion/sedge-grass	3,000	1.1
Shrubland	42,000	15.2
Low shrub	38,000	13.8
Willow	100	<0.1
Mixed	38,000	13.8
Low shrub/wet sedge-grass complex	4,000	1.4
Agricultural land	400	0.1
Disturbed	1,000	0.4
Unvegetated	6,000	2.2
Water	6,000	2.2
Lakes	500	0.2
Rivers	5,000	1.8
Gravel	300	0.1
Total Area	276,000	100

†[1] The Tanana Flats area within this transmission corridor study area (see text) is characterized by extremely complex mosaics of various vegetation types. As a result, various complexes were recognized and mapped.

†[2] Acreages and percentages do not add up to totals for each major vegetation type due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Exhibit E, Vol. 6B, Chap. 3, Table E.3.77 and rounded to the nearest 1000 acres or to one significant figure for values less than 500 (originally based on McKendrick et al., 1982).

upper and middle Susitna Basin, about half of the spruce stands in this area contain contain larch.

The section of the transmission corridor study area between the Tanana River and Fairbanks consists of rolling hills. Open deciduous forests are the predominant vegetation type. Spruce stands are smaller and less common than in the Tanana Flats area. In many of the closed spruce stands, the trees are very short and scrub-like. Very few larch trees are mixed with the spruce in this area.

J.1.2.3.4 Wetlands

Wet sedge-grass tundra and potentially wet spruce areas are known to occur within the transmission corridor study areas. However, McKendrick et al. (1982) and Commonwealth Associates (1982) did not map wetlands in the transmission corridor study areas. As indicated in Section J.1.2 and Table J-5 the wetlands classifications of Cowardin et al. (1979) can be liberally correlated to the vegetation classifications of Viereck and Dyrness (1980). Thus, for this document, the areas of potential wetlands within the Willow-to-Anchorage and Healy-to-Fairbanks transmission corridor study areas and the proposed Healy-to-Willow transmission corridor have been estimated by the methods described in Section J.1.2; the results are summarized in Table J-16.

J.1.2.4 Threatened and Endangered Species

At present, no plant species known to occur in Alaska have been officially listed as threatened or endangered by Federal or state authorities. There are, however, 30 plant taxa under review for possible protection under the Endangered Species Act of 1973, as amended (U.S. Fish and Wildlife Service, 1980, 1983). On the basis of Murray (1980), 9 of these 30 candidate taxa have been identified as having a higher probability than the rest of occurring within the upper and middle Susitna Basin and the lower Susitna River floodplain (McKendrick et al., 1982). Of these nine candidate species (listed in Table J-17), two, Smelkowskia borealis var. villosa and Taraxacum carneocoloratum, have been identified by the Applicant's consultants as having the potential of occurring in the vicinity of the Healy-to-Willow transmission corridor study area (Commonwealth Associates, 1982). A third species, Montia bostockii, was considered to have appropriate habitat within the proposed Healy-to-Willow transmission corridor but it is not known to occur in the general area around that corridor.

To date, none of the nine candidate species listed in Table J-17 nor any of the other candidate taxa under review has been found within the upper and middle Susitna Basin, the lower Susitna River floodplain, or the Healy-to-Willow transmission corridor study area. Surveys of the Willow-to-Anchorage and Healy-to-Fairbanks transmission corridor study areas have not been conducted; however, the U.S. Fish and Wildlife Service has indicated that the likelihood of finding these species in those corridor segments is very low (U.S. Dept. of Interior, 1983: p. 50).

J.1.3 Susitna Development Alternatives

J.1.3.1 Alternative Dam Locations and Designs

The sites of alternative dam locations and designs would all be located within the upper and middle Susitna Basin. Descriptions and definitions of the vegetation types found within the upper and middle Susitna Basin have been provided above in Section J.1.2.1.

Alternative designs for the dams and related facilities would affect essentially the same environment as the proposed designs. Brief descriptions of the vegetation types that are found in the vicinity of the alternative Susitna Basin dam sites and their associated impoundments were derived from Figure E.3.38 in Exhibit E (Vol. 6B, Chap. 3).

Vegetation types found in the vicinity of the Watana I alternative are essentially the same as those described in Section J.1.2.1 for the proposed Watana dam and impoundment, except that proportionally lesser areas of shrubland as well as woodland and open black spruce forest types would likely be affected. This assumption is based on the lower elevation of this alternative dam and the reduced length of its impoundment. For the Reregulating dam alternative (Fig. 2-17), the dam, impoundment, and powerhouse would be located primarily in open spruce and open mixed forest types. The Modified High Devil Canyon alternative (Fig. 2-17) would be located in essentially the same environment as the proposed Devil Canyon dam and impoundment (see Sec. J.1.2.1), except that mixed conifer-deciduous forest located between the Devil Canyon and High Devil Canyon dam sites would not be affected.

J.1.3.2 Alternative Access Routes

The two technically and economically feasible alternative access routes would be located almost entirely within the upper and middle Susitna Basin (see Sec. 2.2.2.4 and Fig. 2-13). Descriptions and definitions of the vegetation types found within the upper and middle Susitna Basin have been previously discussed in Section J.1.2.1. Brief descriptions of the vegetation types

Table J-16. Estimated Areal Extent and Percentage of Total Area Covered by Potential Wetlands within the Willow-to-Anchorage and Healy-to-Fairbanks Transmission Corridor Study Areas and the Proposed Healy-to-Willow Transmission Line Corridor

	Willow-to-Anchorage†[1]		Healy-to-Willow†[1]		Healy-to-Fairbanks†[1]	
Wetland Classification	Potential Acreage†[2,3]	Percentage of Transmission Corridor Study Area†[4]	Potential Acreage†[2,5]	Percentage of Transmission Corridor†[4]	Potential Acreage†[2,3]	Percentage of Transmission Corridor Study Area†[4]
Palustrine forested, needle-leaved evergreen	14,000	14.7	830	18.0	83,000	30.1
Palustrine forested, broad-leaved deciduous	700	0.7	340	7.4	0	0
Palustrine scrub-shrub, broad-leaved deciduous	5,000	5.3	1,800	39.1	42,000	15.2
Palustrine or lacustrine emergent, persistent	23,000	24.2	270	5.9	6,000	2.2
Complexes of Palustrine forested, scrub-shrub, and emergent	0	0	0	0	23,000	8.3
Lacustrine	2,000	2.1	0	0	500	0.2
Riverine	0	0	0	0	6,000	2.2
Total Potential Wetland	45,000	47.4	3,300	71.7	160,000	58.0

†[1] Acreages and percentages do not add up to totals due to rounding errors.

†[2] These areas should be considered extremely liberal, see explanation in text.

†[3] Values converted from hectares as given in McKendrick et al. (1982) to acres and rounded to nearest 1000 acres or one significant figure if values are less than 1,000.

†[4] Percentages calculated by dividing acreages by total area of transmission corridor study area for the Willow-to-Anchorage and Healy-to-Fairbanks segments and by total area of proposed transmission line corridor for the Healy-to-Willow segment. See Tables J-13, J-15, and J-14, respectively.

†[5] Calculated from data and maps in Commonwealth Associates (1982). The values presented here represent the additional clearing of the corridor from the 110 ft (34 m) given by Commonwealth Associates (1982) to a total width of 300 ft (91 m) from Gold Creek to Healy and 400 ft (122 m) from Gold Creek to Willow. Thus, the potential wetland areas presented in this table represent areas that would occur within a 190-ft (58-m) wide corridor from Gold Creek to Healy and a 290-ft (88-m) wide corridor from Gold Creek to Willow. Areas represented are those that would actually be crossed by the proposed transmission line corridor, rounded to two significant figures.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Tables J-13, J-14, and J-15 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Table J-17. Plant Species under Review as Threatened or Endangered with the Highest Probability of Occurrence within Areas that Would be Affected by the Proposed Project†[1]

Scientific Name	Common Name
Aster yukonensis	Yukon aster
Cryptantha shackletteana	Catseye
Eriogonum flavum var. aquilinum	Wild buckwheat
Erysimum asperum var. angustatum	Wallflower
Montia bostockii	-†[2]
Podistera yukonensis	-
Smelowskia borealis var. villosa	-
Smelowskia pyriformis	-
Taraxacum carneocoloratum	-

†[1] All species listed are under review for inclusion under the Endangered Species Act of 1973, as amended (U.S. Fish Wildlf. Serv., 1980; 1983).

†[2] "-" = No common name.

Source: Modified from McKendrick et al. (1982).

found along the northern and southern alternative access corridors are presented below. These descriptions are based on material in Exhibit E (Vol. 9, Chap. 10, p. E-10-42 - E-10-43, and Figs. E.10.7 - E.10.8) and Supplemental Information to Exhibit E (Vol. 9, Chap. 10, June 30, 1983, p. 10-14-1 - 10-14-2 and supplemental attachments SA10-14-1 - SA10-14-2).

The northern access alternative consists of two segments. The route from Hurricane to Devil Canyon would traverse mostly white spruce and mixed conifer-deciduous forest types, as well as tall shrub communities and some riparian and wetland areas. The north-side route between Devil Canyon and Watana would cross mostly white spruce, mixed conifer-deciduous forest, and tall shrub types along Portage Creek and over to Devil Creek. At the higher elevations between Devil Creek and Watana the route would cross mostly shrublands and various tundra types.

The southern access alternative has three segments. The predominant vegetation type that would be crossed by the route between Gold Creek and Devil Canyon is mixed conifer-deciduous forest. Between Hurricane and Devil Canyon the route would be essentially the same as that described above for the northern access alternative. The south-side route from Devil Canyon to Watana would traverse a complex mosaic of vegetation types. From Devil Canyon east, the route would cross mixed forest and tall shrub communities, then mostly low shrub and tundra types, and finally, in the far eastern portion of the route, mixed forest, spruce forest, and low shrubland, including numerous wetland areas near Prairie Creek, Stephan Lake, and Tsusena and Deadman creeks.

J.1.3.3 Alternative Power Transmission Routes

The alternative power transmission line routes are divided into three study areas: northern, southern, and central (Figs. 2-14 through 2-16). Within these study areas, one (northern), six (central), and two (southern) technically and economically acceptable alternative corridors have been identified in addition to the proposed corridors (Exhibit E, Vol. 9, Chap. 10, Table E.10.24). Brief descriptions of the vegetation types found along the alternative corridors are presented below. The descriptions are based on Exhibit B (Tables B.39 - B.41) and Supplemental Information to Exhibit E (Vol. 9, Chap. 10, June 30, 1983, p. 10-20-1 - 10-20-7). Descriptions and definitions of the vegetation types have been previously provided in Section J.1.2.1.

J.1.3.3.1 Northern Study Area

Corridor ABDC: About half spruce forests, one-third low shrub, remaining areas are deciduous forest, mixed forest, and tall shrub; many wet areas likely in segment BDC.

J.1.3.3.2 Central Study Area

Corridor ABCD: Mostly black spruce forest (potentially wet) with some low shrub in segment AB; equal amounts of mixed conifer-deciduous forest, spruce forest, and low shrub in segment BC; mostly mixed conifer-deciduous forest in segment CD.

Corridor ABCF: Segments AB and BC described above; mostly tall shrub and mixed conifer-deciduous forest in segment CF.

Corridor ABECD: Segments AB and CD described above; woodland spruce and bogs near Stephan Lake, remaining areas in segment BEC include low shrub, tundra, tall shrub, and mixed conifer-deciduous forest.

Corridor ABECF: Segments AB, BEC, and CF described above.

Corridor AJCF: Mostly low shrub and tundra types with some tall shrub in segment AJ; tall and low shrubland and mixed conifer-deciduous forest in segment JC; segment CF described above.

Corridor CJAHI: Segments CJ and JA described above; mostly low and tall shrubland with some woodland spruce in segment AH; tundra types and shrubland probably predominate along segment HI.

J.1.3.3.3 Southern Study Area

Corridor ABC': About half mixed conifer-deciduous forests, about one-fourth deciduous (balsam poplar) forest (mostly in segment BC), with lesser amounts of wet sedge-grass marshes, spruce bogs, and shrubland.

Corridor AEFC: Mostly mixed conifer-deciduous forest in northern half of segment AEF, with most of southern half wet sedge-grass bogs and black spruce forest; mixture of spruce forests, mixed conifer-deciduous forests, wet sedge-grass marshes, and black spruce bogs in segment FC.

J.1.3.4 Alternative Borrow Sites

The only alternative borrow sites not discussed in Section J.1.2.1 are borrow sites B, C, J, and L (Figs. 2-2 and 2-6). Descriptions of the vegetation located within these alternative borrow sites are based on Figure J-2 and Exhibit E (Vol. 9, Chap. 10, p. E-10-83 - E-10-104). Borrow site B is covered mostly by mixed conifer-deciduous forest with a heavy understory and marshy conditions on the south-facing side. Borrow site C is covered by a mixture of woodland spruce forest and shrubland (mostly low shrub). Tundra types are also found at higher elevations on the valley slopes. Borrow site J is contained within the Susitna River. Borrow site L is a very small site covered with deciduous forest and a marshy area of tall shrub.

J.1.3.5 Threatened and Endangered Species

Consideration of threatened and endangered plant species for the Susitna development alternatives is the same as that presented for the proposed project in Section J.1.2.4.

J.1.4 Non-Susitna Generation Alternatives

Except as noted, the following descriptions of vegetation occurrence associated with potential development of the natural-gas-fired generation scenario, the coal-fired generation scenario, and the combined hydro-thermal generation scenario are based on the vegetation map presented in Section J.1.1 (Fig. J-1). The vegetation types delineated on that map are described in Table J-1.

J.1.4.1 Natural-Gas-Fired Generation Scenario

J.1.4.1.1 Beluga and Chuitna Rivers

Vegetation in the lower Beluga River area is mostly upland spruce-hardwood forest except near the coast, where wet sedge-grass predominates. The Chuitna River originates in an area of high brush and then passes through upland spruce-hardwood forest on its way to Cook Inlet.

J.1.4.1.2 Kenai

North of Kenai the vegetation is primarily lowland spruce-hardwood forest, although a relatively narrow strip of upland spruce-hardwood forest occurs along the coast.

J.1.4.1.3 Anchorage

Southeast of Anchorage the natural vegetation has probably been altered somewhat by development activities. Undisturbed or relatively undisturbed areas are likely to be bottomland spruce-poplar forest, upland spruce-hardwood forest, or lowland spruce-hardwood forest.

J.1.4.2 Coal-Fired Generation Scenario

J.1.4.2.1 Willow

Vegetation in the Willow area is primarily lowland spruce-hardwood forest, although bottomland spruce-poplar forest is found along the Susitna River.

J.1.4.2.2 Nenana

Along the Tanana and Nenana rivers near Nenana, the vegetation is primarily bottomland spruce-poplar forest. Farther away from the rivers the predominant vegetation type is lowland spruce-hardwood forest.

J.1.4.2.3 Healy (Mining Area)

In the vicinity of Healy, where the coal would be mined (Fig. 1-14), vegetation along the Nenana River and its tributaries is upland spruce-hardwood forest. Away from the river, at higher elevations, the vegetation grades into moist tundra and alpine tundra.

J.1.4.2.4 Cook Inlet Area

Vegetation occurring in likely locations for siting of gas combustion turbines in the Cook Inlet area has been described for the natural-gas-fired generation scenario in Section J.1.4.1.

J.1.4.3 Combined Hydro-Thermal Generation Scenario

J.1.4.3.1 Johnson

Along the Tanana River near the Johnson alternative site the vegetation is mostly bottomland spruce-poplar forest; farther away from the Tanana River floodplain and along the Johnson River, the vegetation is mostly upland spruce-hardwood forest. However, there are also smaller areas of lowland spruce-hardwood forest and low shrub, muskeg bog as well as areas of moist tundra and alpine tundra at the higher elevations.

J.1.4.3.2 Keetna

Bottomland spruce-poplar forest types predominate along the Talkeetna River near the Keetna alternative site. These forests grade into upland spruce-hardwood forests away from the floodplain. At higher elevations above the river the vegetation consists of moist tundra types (e.g., mesic sedge-grass tundra and mat and cushion tundra) similar to those found on the benches above the Susitna River Canyon.

J.1.4.3.3 Snow

Forested areas near the Snow alternative site are mostly coastal western hemlock-Sitka spruce forest; however, cottonwoods and willows probably dominate the river valleys and floodplains. Tall shrub communities, dominated by alder, grade into alpine tundra types above the tree line.

J.1.4.3.4 Browne

Vegetation along the Nenana River near the Browne alternative site is mostly bottomland spruce-poplar forest. Farther from the river the vegetation grades into lowland spruce-hardwood communities. About 10 mi (16 km) upstream from the dam site, upland spruce-hardwood forest communities predominate along the river. At higher elevations the vegetation grades into moist tundra and alpine tundra.

J.1.4.3.5 Chakachamna Lake

The vegetation on the steep slopes surrounding Chakachamna Lake can be generally classified as tall shrubland with alpine tundra and bare rock at higher elevations. The tall shrub type consists of an abundance of black cottonwood, Sitka alder, and paper birch, with diamondleaf and feltleaf willow abundant in some areas. This vegetation type is also found on the canyon walls above the McArthur, Chilligan, Neacola, Ignita, and Nagishlamina rivers (Bechtel, 1983).

In the Chakachatna River canyon and on the floodplains of rivers flowing into Chakachamna Lake, the tall shrub type is characterized by Sitka alder, paper birch, white spruce, and diamondleaf and feltleaf willows. As the rivers drop to lower elevations on the way to Cook Inlet, riparian communities are characterized by black cottonwood, thinleaf alder, paper birch, and numerous willow species (Bechtel, 1983).

Large, low-shrub bogs are found on flat, poorly drained areas as the topography flattens out to the upper Cook Inlet coastal plain. These bogs are dominated by shrubs such as resin birch, bog blueberry, and narrow-leaf Labrador tea and by sedges and grasses. Black spruce, black cottonwood, alder, and paper birch are found in later successional stands. Sedge-grass coastal marshes cover most of the area within 1 mi (1.6 km) of Cook Inlet, as well as some areas along the McArthur River. Intermediate between the coastal marshes and the bogs are poorly drained areas of black spruce forest, with an understory of diamondleaf willow, alder, sedges, and grasses. These areas differ from the bogs in the lack of floating vegetation mats and the absence of black cottonwood (Bechtel, 1983).

J.1.4.3.6 Nenana, Chuitna River, Anchorage

Vegetation in the vicinity of Nenana, the Chuitna River, and Anchorage, where thermal units for this scenario would probably be sited, have been described in Sections J.1.4.1 and J.1.4.2.

J.1.4.4 Threatened and Endangered Species

Consideration of threatened and endangered plant species for non-Susitna power generation alternatives is essentially the same as that presented in Section J.1.2.4. On the basis of Murray (1980), two additional species, *Oxytropis kokrinensis* and *Thlaspi arcticum*, have some possibility of occurrence--*Oxytropis kokrinensis* at Johnson, Browne, and the Nenana/Healy areas, and *Thlaspi arcticum* at Snow and Chakachamna Lake and in the Cook Inlet region.

J.2 ENVIRONMENTAL IMPACTS

J.2.1 Proposed Project

J.2.1.1 Watana Development

J.2.1.1.1 Construction

Potential impacts to terrestrial plant communities and wetlands resulting from construction of the Watana development can be divided into three categories (1) the direct removal of vegetation, (2) indirect vegetation loss or damage, and (3) alteration of plant communities. The first category generally constitutes the most severe impacts and is the most quantifiable of the three categories. The second and third categories are not mutually exclusive in that indirect vegetation loss or damage often results in alteration of plant communities.

Vegetation Removal

During the construction and filling of the Watana development, approximately 36,000 acres (14,600 ha) of vegetation would be directly removed by clearing or inundation. Of this area approximately 31,000 acres (12,500 ha) of vegetation would be permanently lost due to construction of the dam, spillways, impoundment, permanent village, and airstrip. Vegetation cleared for the construction camp and village, construction roads, contractor work areas, and borrow areas would total approximately 5,200 acres (2,100 ha). However, the potential for vegetation establishment and growth on these areas would only be temporarily lost since these facilities would only be required during construction.

The area of vegetation that would be permanently lost represents about 1% of all vegetation and about 3% of the forested areas within the entire upper and middle Susitna Basin above Gold Creek (Table J-18). Most of the vegetation lost (over 60%) would be woodland and open spruce forest; however, these areas only amount to approximately 2% of the woodland spruce forest and 3% of the open spruce forest in the upper and middle Susitna Basin. In contrast, the actual acreages of birch and mixed forest types removed would be less than spruce forest types, but the areas of these types that would be lost represent at least 5% of the total area covered by each vegetation type within the upper and middle Susitna Basin (Table J-18). The most severely impacted vegetation types would be open and closed birch forest, but the proportion of these types lost, as presented in Table J-18, is a gross overestimation caused by mapping scales. Since many birch stands were generally found to be relatively small (McKendrick et al., 1982), most were not mappable at the 1:250,000 scale used for the upper and middle Susitna Basin, but many more stands were mappable at the 1:63,360 scale used to compute vegetated areas affected by Watana facilities. Assuming that birch stands are usually found on relatively warm slopes near rivers (see Sec. J.1.2.1.1), better estimates of the proportions of birch forest types that might be lost (ca. 20% for both closed and open stands) may be based on estimates of birch forest types occurring within 10 mi (16 km) of the Susitna River between Gold Creek and the Tyone River (which was mapped at a scale of 1:63,360; see Table J-8). The actual proportions of open and closed birch forests that would be lost are probably somewhere between 10 and 20% of the total for the upper and middle Susitna Basin.

Vegetation that would be cleared for temporary facilities and borrow areas represent about 0.2% of the vegetation within the upper and middle Susitna Basin (Table J-19). These areas presently support approximately equal areas of forest and shrubland types and a relatively smaller proportion of tundra types. According to the schedule presented in Exhibit E (Vol. 6A, Chap. 3,

Table J-18. Acreage of Vegetation Types that Would be Permanently Lost as a Result of the Watana Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

Vegetation Type	Vegetated Area Lost (acres)†[1]					Percentage of Basin Total for Respective Type†[2]
	Dam and Spillways	Impoundment	Permanent Village	Airstrip	Total	
Forest	84	27,000	0	0	27,000	3.1
Woodland black spruce	20	9,600			9,600	2.3
Woodland white spruce		980			980	
Open black spruce		7,100			7,100	3.1
Open white spruce		1,900			1,900	
Open birch	2	800			810	40.5†[3]
Closed birch	32	1,100			1,200	120.0†[3]
Closed balsam poplar		7			7	†[4]
Open mixed	12	3,300			3,300	5.7
Closed mixed	17	1,900			1,900	4.9
Tundra	0	210	0	0	210	0.02
Wet sedge-grass		210			210	1.8
Shrubland	110	4,100	67	42	4,400	0.3
Open tall shrub	15	560			580	0.4
Closed tall shrub	42	710			750	
Birch shrub	2	1,100	37	32	1,200	1.4
Willow shrub		160			160	0.6
Mixed low shrub	54	1,600	30	10	1,700	0.1
Herbaceous	0	110	0	0	110	†[4]
Unvegetated	32	5,200	20	0	5,300	0.9
Rock	2	150			150	0.05
River	30	5,000			5,000	13.9
Lake		94	20		110	0.2
Total Vegetated Area	198	31,000	67	42	31,000	0.9
Total Area	230	36,000†[5]	86	42	37,000	0.9

†[1] Acreages converted from hectares as given in the source and rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-7.

†[3] This is an overestimation caused by differences in mapping scales (see text).

†[4] These vegetation types were not quantified in Table J-7 (see text).

†[5] The total area that would be inundated by the Watana impoundment as calculated by McKendrick et al. (1982) in the vegetation studies differs slightly from the impoundment area stated in Section 2.1.2.1. This is probably due to differences in mapping techniques.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.83 (Revised), p. 3B-7-4, which is based on the 1:63,360 maps (Fig. J-2).

Table J-19. Acreage of Vegetation Types that Would be Temporarily Lost and Would Require Rehabilitation as a Result of the Watana Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin†[1]

Vegetation Type	Vegetated Area Lost (acres)†[2]										Percentage of Basin Total for Respective Type†[5]
	Construction Camp	Temporary Village	Borrow Areas†[3]						Contractor Work Areas and Construction Roads†[4]	Total	
			A	D	E	F	H	I			
Forest	0	0	450	130	440	200	1,100	84	200	2,600	0.3
Woodland black spruce			440	40			550			1,000	
Woodland white spruce					180	170				350	0.3
Open black spruce							300	37		340	
Open white spruce			5		150	27				190	0.2
Closed birch				12					21	33	3.3
Open mixed				79			260		73	410	0.7
Closed mixed					120	2		47	100	270	0.7
Tundra	0	0	170	20	0	0	0	0	0	190	0.02
Wet sedge-grass				20						20	0.2
Mat and cushion			170							170	0.1
Shrubland	160	86	200	550	0	490	94	0	840	2,400	0.2
Open tall shrub			2							2	
Closed tall shrub			2	30					120	160	0.05
Birch shrub	84	49	10	220		480				840	1.0
Willow shrub						10	42			52	0.2
Mixed low shrub	72	37	190	310			52		720	1,400	0.1
Unvegetated	0	0	2	5	0	0	0	0	0	7	<0.01
Rock				5						5	<0.01
Lake			2							2	<0.01
Total Vegetated Area	160	86	820	700	440	690	1,200	84	1,000	5,200	0.2
Total Area	160	86	820	710	440	690	1,200	84	1,000	5,200	0.1

†[1] The use of the word, temporarily, implies that the area would eventually be rehabilitated.

†[2] Acreages converted from hectares as given in the source and rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[3] Values only include acreages located above the maximum impoundment elevation.

†[4] Values estimated by determining total acreages within 10 mi (16 km) of the Susitna River (Table J-8) of types that might be affected (according to Exhibit E, Vol. 6A, Chap. 3, p. E-3-276), and determining what proportion each type represents of the total for all types affected. These proportions were then multiplied by the estimated total acreage of work areas and roads to give estimates of each type that might be affected.

†[5] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-7.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.83 (Revised), p. 3B-7-4, which is based on the 1:63,360 maps (Fig. J-2).

p.E-3-276 - E-3-277), temporary facilities and borrow areas would be removed and/or regraded and rehabilitated by the end of the construction and reservoir-filling period (within 11 years of the start of construction). General rehabilitation procedures planned by the Applicant have been described in Section J.3.1.3 and Exhibit E (Vol. 6A, Chap. 3, p.E-3-279 - E-3-281).

If soils can be adequately restored on rehabilitated areas, it is likely that at least some vegetation would reestablish rather rapidly because of the disturbance-adapted nature of subarctic plant species and communities (Van Cleve, 1978; Webber and Ives, 1978; Chapin and Chapin, 1980; Viereck and Schandelmeier, 1980; Van Cleve and Viereck, 1981). However, in most (if not all) instances, it would be readily apparent for some time that the area has been disturbed. The rate at which plant communities in rehabilitated areas replace the original pattern of lost vegetation or blend in with surrounding communities would depend on the rates of plant reestablishment and succession on the rehabilitated sites and in surrounding areas. The rate and direction of plant reestablishment and succession at each site might vary depending on numerous factors, such as: size of the affected area; vegetation types in surrounding areas; changes in physical, chemical, and microbial properties of soils during storage; viability of seeds and vegetative propagules in replaced soils; whether or not introduced species were initially seeded for erosion control; site slope, aspect, and elevation; soil type; soil nutrient content; soil moisture and drainage conditions; presence of permafrost; soil texture and degree of compaction; degree of herbivore use; and fire occurrence. Based on the rates of plant succession reported for floodplains and glacial moraines and those observed following fires (Viereck, 1966; Viereck and Schandelmeier, 1980; Van Cleve and Viereck, 1981), it might be 150 years or more (perhaps even 250 to 300 years) before the original vegetation types removed from some areas (generally those occupied by later successional stages) were replaced with similar plant communities. Of course, it might take less time if conditions are optimal.

On the other hand, replacement of later successional stands by earlier seral stages might be beneficial for wildlife because early seral stages generally provide more high-quality forage than do later seral stages (Wolff, 1978; Wolff and Zasada, 1979; Viereck and Schandelmeier, 1980). In many cases, the long-term effects of heavy browsing might be to increase production through increased lateral branching (Viereck and Dyrness, 1979; Wolff and Zasada, 1979). However, it is possible that some of the rehabilitated areas could be over-browsed which might cause vegetation stunting, poor cover, erosion, and decreased stability of the developing plant community. Negative effects associated with heavy browsing are probably most likely to occur in areas where stresses are at a high level (e.g. low nutrient reserves) (Wolff, 1978; Wolff and Zasada, 1979).

Many of the vegetation types that would be cleared during construction of Watana facilities can also be considered wetlands. However, it is difficult to accurately predict the actual acreages of various wetland types that would be lost because the Applicant has not conducted a detailed wetland mapping program which includes consideration of soils and topography as well as plant communities. Lacking better information, extremely liberal estimates of potential wetlands that would be lost due to construction of the Watana development (Tables J-20 and J-21) have been made on the basis of the Viereck and Dyrness (1980) vegetation classification system (see Table J-5). The areas presented in Tables J-20 and J-21 really represent areas that would be lost in which wetlands potentially could occur.

Thus, as a liberal estimate, 28,000 acres (11,300 ha) of wetlands, primarily palustrine forested, needle-leaved evergreen types, would be permanently lost as a result of Watana construction and filling (Table J-20). This acreage represents about 1.3% of the potential wetland area in the upper and middle Susitna Basin. Although less than 250 acres (100 ha) of palustrine and lacustrine emergent, persistent wetlands would be lost, these areas account for almost 2% of the type within the upper and middle Susitna Basin. Additionally, about 14% of the riverine type within the upper and middle Basin would be lost.

Construction of temporary facilities and borrow areas for the Watana development could potentially affect an additional area of approximately 4,200 acres (1,700 ha) of wetlands (Table J-21). This area amounts to approximately 0.2% of the wetlands within the upper and middle Susitna Basin. Although the land areas where these temporary facilities had been located would be physically rehabilitated, it is impossible to predict whether wetlands that originally occurred in these areas would be restored. Since localized drainage patterns and terrain might often be affected or purposefully changed during construction of project facilities or excavation of borrow areas, the potential for and the feasibility of reestablishing wetland conditions must be considered on a case-by-case basis. Conversely, construction of Watana facilities might change local drainage patterns around the facilities, resulting in the creation of new wetlands nearby (Berg, 1980). However, the Applicant has indicated that efforts would be taken to avoid wetlands wherever possible during construction of project facilities and to minimize potential major alterations to drainage patterns through proper engineering design (Exhibit E, Vol. 6A, Chap. 3, p. E-3-256 and E-3-290).

Table J-20. Acreage of Potential Wetland Types that Would be Permanently Lost as a Result of the Watana Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

Wetland Type	Potential Wetland Area Lost (acres)†[1]					Percentage of Basin Total for Respective Type†[2]
	Dam and Spillways	Impoundment	Permanent Village	Airstrip	Total	
Palustrine forested, needle-leaved evergreen	20	20,000	0	0	20,000	2.6
Palustrine forested, broad-leaved deciduous	0	7	0	0	7	0.7
Palustrine scrub-shrub, broad-leaved deciduous	57	2,900	67	42	3,000	0.2
Palustrine or lacustrine emergent, persistent	0	210	0	0	210	1.8
Lacustrine	0	94	20	0	110	0.2
Riverine	30	5,000	0	0	5,000	13.9
Total Potential Wetland Area	110	28,000	86	42	28,000	1.3

†[1] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, converted from hectares as given in the source, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-12.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-18 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Table J-21. Acreage of Potential Wetland Types that Would be Temporarily Lost and Would Require Rehabilitation as a Result of the Watana Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin†[1]

Vegetation Type	Potential Wetland Area Lost (acres)†[2]										Percentage of Basin Total for Respective Type†[5]
	Construction Camp	Temporary Village	Borrow Areas†[3]						Contractor Work Areas and Construction Roads†[4]	Total	
			A	D	E	F	H	I			
Palustrine forested, needle-leaved evergreen	0	0	450	40	330	200	850	37	0	1,900	0.3
Palustrine scrub-shrub, broad-leaved deciduous	160	86	200	520	0	490	94	0	720	2,300	0.2
Palustrine or lacustrine emergent, persistent	0	0	0	20	0	0	0	0	0	20	0.2
Lacustrine	0	0	2	0	0	0	0	0	0	2	<0.01
Riverine	0	0	0	0	0	0	0	0	0	0	0
Total Potential Wetland Area	160	86	640	580	330	690	940	37	720	4,200	0.2

†[1] The use of the word, temporarily, implies that the area would eventually be rehabilitated.

†[2] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, converted from hectares as given in the source, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[3] Values only include potential wetland acreages located above the maximum impoundment elevation.

†[4] Values estimated by determining total acreages within 10 mi (16 km) of the Susitna River (Table J-8) of types that might be affected (according to Exhibit E, Vol. 6A, Chap. 3, p. E-3-276), and determining what proportion each type represents of the total for all types affected. These proportions were then multiplied by the estimated total acreage of work areas and roads to give estimates of each type that might be affected.

†[5] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-12.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-19 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Indirect Vegetation Loss or Damage and Alteration of Plant Communities

Vegetation loss or damage could occur as a result of erosion and slumpage on slopes surrounding the impoundment or other Watana facilities (Baxter, 1977; Baxter and Glaude, 1980; Jassby, 1980). Two major causes of reservoir slope instability are expected to be reservoir-induced changes in ground water regimes and thawing of permafrost (Exhibit E, Vol. 7, Chap. 6, p. E-6-31). More localized erosion would probably occur as a result of construction-related factors, such as: altered drainage patterns, blowdown of trees near cleared areas, and destabilization of soils exposed by clearing.

Although the areal extent of slope instability along the Watana reservoir shoreline cannot be reliably quantified in advance, the Applicant has calculated, on the basis of aerial photographic interpretation and limited field reconnaissance, that about 15,000 acres (6,000 ha) of land adjacent to the reservoir shoreline might be affected to some degree by beaching, flow, or block slides (Supplemental Information to Exhibit E, Vol. 7, Chap. 6, Item 7). It is anticipated that these slope failures would be a long-term, progressive activity initiated during construction and continuing during operation, and that some portion of these areas would be susceptible to erosion and loss of vegetation.

There are three major areas where erosion, slumpage, and subsequent vegetation loss would be expected. The largest area occurs on the south side of the canyon from the south abutment of the Watana dam site (RM 184) to the Vee Canyon-Oshetna River area (RM 225 - 233). The slopes in this reach (see Exhibit E, Vol. 7, Chap. 6, Figs. E.6.31 - E.6.45), especially to RM 218 are underlain by discontinuous permafrost that is 200- to 300-ft (60- to 90-m) deep. Vegetation types that could potentially be affected by erosion and slumpage in this reach include woodland and open black spruce and low shrub types. From the Oshetna River-Goose Creek area (RM 233) to the headwaters of the reservoir (RM 243), cliffs of frozen silts and clays are considered susceptible to slumpage and erosion. Woodland black spruce and birch shrub are the predominant vegetation types along this reach. The third area consists of the slopes along the north side of the canyon from the Watana dam site to the Watana Creek area (RM 194). In this area unconsolidated glacial outwash occurs within and above the drawdown zone. Vegetation types in this area include woodland and open black spruce, birch shrub, and low mixed shrub. However, the exact locations and acreages of specific vegetation types that would be affected by erosion and slumpage cannot be reliably quantified at this time (Exhibit E, Vol. 6A, Chap. 3, p. E-3-226 and p. E-3-285 - E-3-286).

Increased winds caused by the greater fetch associated with clearing of the impoundment area (Baxter and Glaude, 1980) could result in blowdown of trees near the impoundment. Blowdown has been identified as a problem in cleared areas (Todd, 1982). The areas likely to suffer the greatest damage are the stands of woodland black spruce south of the Watana dam site, because of predominately northeasterly winds and the typically shallow rooting depth [12 in (30 cm)] of black spruce.

Several other factors associated with the construction of the Watana development might cause relatively localized vegetation damage and/or alterations in plant communities of an unquantifiable nature. For example, changes in drainage patterns and surface hydrology would be caused by such construction activities as clearing, ditching, soil stockpiling, and borrow site excavation (Berg, 1980). Some soils might become waterlogged; others might accumulate less moisture. Soil aeration conditions and nutrient cycling processes could also be affected. The active layer of permafrost areas might change, and cleared soils might freeze and thaw deeper and earlier than when insulated by vegetation. Such changes in surface and soil water regimes might directly alter the composition or productivity of nearby plant communities or might cause erosion thereby indirectly affecting vegetation. On permafrost-free sites, rainfall- and snowmelt-induced sheet-rill erosion might be on the order of 10 to 20 times greater on cleared sites where the organic layer is removed then on sites where ground layer vegetation and the organic layer are left intact (Aldrich and Slaughter, 1983).

Fugitive dust from cleared areas and borrow sites might accumulate on vegetation or cause abrasive damage. Relatively thick accumulations can potentially retard snowmelt; whereas, relatively thin accumulations may speed up snowmelt (Drake, 1981). Either situation can affect plant phenology. Direct effects of dust on plants would vary depending on factors such as thickness of accumulation, chemical composition of the dust, and plant species. In tundra vegetation types, mosses and lichens (particularly Sphagnum spp. and lichens in the family Cladoniaceae) appear to be generally less tolerant of dusting than vascular plants, presumably due to factors such as their low growth form, shallow surface anchoring, and lack of cuticle (Everett, 1980). Growth of some species, notably the cottongrasses, might actually be stimulated by dusting conditions. Communities with a high abundance of Sphagnum and/or fruticose lichens are likely to be affected more than other communities. Permafrost might be affected in these communities if the thickness of the insulating organic layer is reduced significantly.

Clearing as well as the indirect loss or damage of vegetation might affect the abundance of insects, decay organisms, and disease-causing agents. Changes in the abundance of these organisms could have further indirect effects on vegetation.

There might be increased incidences of fires due to the greater numbers of people in the area during construction. Although fire is a natural factor affecting plant community distribution patterns in the region (Viereck and Schandelmeier, 1980), Susitna development-related fires would cause plant community changes similar to those caused by natural fires. However, the frequency, duration, intensity, and area of the fires might be altered by comparison to naturally caused fires, and this could have some effect on plant community distributions.

There would be other forms of indirect loss, damage, and alteration of vegetation due to increased human activity in the Watana development area during construction. Nonessential disturbance of vegetation surrounding the camp, village, airstrip, and construction areas caused by workers and others cannot be avoided entirely. The Applicant has stated that a monitoring program would be instituted to determine areas disturbed by such activities and that these areas would be rehabilitated along with those areas identified in Table J-19 (Exhibit E, Vol. 6A, Chap. 3, p. E-3-281 - E-3-282). Increased use of off-road vehicles (ORV) and all-terrain vehicles (ATV) might also occur in the development area resulting in increased erosion, subsidence, additional localized vegetation loss or damage, and/or alteration of plant communities. The effects of ORV/ATV use would probably be most severe as a result of summer use and in areas with permafrost, in wetlands, in areas with high soil moisture content, on deep gravel-free soils, on slopes, and in tundra vegetation types (Rickard and Brown, 1974; Gersper and Challinor, 1975; Challinor and Gersper, 1975; Sparrow et al., 1978). Plant recovery would be less likely if the organic layer was severely disturbed and root systems were destroyed (Rickard and Brown, 1974). In areas where the organic layer is totally removed it may take 100 years or longer for rebuilding of an organic mat capable of retaining nutrients within the system (Chapin and Van Cleve, 1978).

The results of ORV/ATV usage are quite variable depending on factors such as the amount and frequency of use, degree of disturbance, soil type, terrain, drainage and permafrost conditions, latitude, and vegetation type. Although most studies have been conducted in arctic tundra areas and may not be directly applicable to the subarctic tundra, shrub, and forest communities of the Susitna Basin area, they do afford some idea of potential consequences of increased ORV/ATV usage in the Susitna Basin.

Working in arctic tundra near Barrow, Gersper and Challinor (1975) reported that, six years after perturbation, soils disturbed by several years of infrequent tracked-vehicle passage had higher bulk densities and temperatures, accelerated and deeper thaw, and lower moisture contents than nearby undisturbed soils. In addition, soils within the track scars had lower (negative) redox potentials, higher concentrations of exchangeable bases, higher base saturation and pH, and higher concentrations of soluble nutrients in the soil solution. Vegetation growing in the track scars exhibited higher nutrient concentrations, increased productivity due largely to increased plant size, and differences in species composition when compared to undisturbed soils (Challinor and Gesper, 1975). In a later study, Chapin and Shaver (1981) examined the effects of various degrees of previous ORV/ATV disturbance along topographic moisture gradients within wet, mesic, and dry graminoid-dominated tundra communities near the Fairbanks-Prudhoe Bay haul road. They found that the disturbed soils had higher temperatures, increased thaw depths, and higher concentrations of available phosphate than undisturbed soils; but the soils did not differ consistently in bulk density, volumetric moisture content, pH, or organic matter content. Fewer species were found in the vehicle tracks than in undisturbed controls, and this was associated with a decrease in the abundance of shrubs and by increased dominance of a few graminoid species. There was a strong relationship between soil moisture and leaf biomass and a tendency for increased biomass on disturbed soils by comparison to controls at wet to mesic sites, but the reverse was true for dry sites. Chapin and Shaver concluded that improved nutrient status on the disturbed sites, however it is achieved, leads to higher productivity due to increases in graminoid abundance relative to shrubs and to increased tiller density.

Sparrow et al. (1978) studied ORV effects more representative of the Susitna Basin at locations along the Denali Highway. On heavily used trails (more than 12 vehicles per year) the surface layer of living material had been killed, and the organic layer was no longer present because the churning action of the vehicles had mixed the organic material with the upper inches of mineral soil. On one site where a portion of the trail had been abandoned, water erosion had caused the formation of gullies 20 to 25 ft (6 to 8 m) wide and up to 10 ft (3 m) deep. The sides of the gullies were collapsing, indicating that gradual expansion in gully width was still occurring. On lesser used trails, a layer of dead undecomposed organic material remained on the soil surface. Wet areas were often the most heavily disturbed with ponding of water causing quagmires. To avoid these areas drivers often tried to circumvent them, thereby gradually increasing the width of disturbance. The depth to permafrost was usually much greater in the trails than for nearby undisturbed soils. Soil bulk densities increased in comparison to controls in trails with moderate to severe disturbance, which was caused by moderate (6 to 12 vehicles per year) to heavy usage. Vegetation was totally lacking on heavily used trails and only occurred between the tracks on some lesser used trails. Taller shrubs such as willow and resin birch seemed most susceptible to damage and were most reduced on trails receiving light (less than six vehicles per year) to moderate use. Low-growing ericaceous shrubs, sedges, and grasses tended to survive on these trails in similar proportions to those found on nearby undisturbed soils. In poorly drained areas, sedges were often the only surviving species, especially on active trails.

J.2.1.1.2 Operation

Operation of the Watana facility would result in continuation of some construction-related impacts such as increased incidence of fires, and vegetation loss or damage due to ORV and ATV use, erosion, and permafrost thaw. In addition, Watana operation would affect vegetation through regulation of downstream flows and mesoclimatic changes.

Effects of Regulated Flows

The regulated flows associated with Watana operation would affect the development of riparian communities downstream of the dam site. Specific effects are difficult to predict and quantify since they would vary at particular locations depending on river morphology and distance from the dam. The following discussion of potential impacts is based on predictions of river staging, water temperatures, and ice regimes presented in Exhibit E (Vol. 5A, Chap. 2). In general, regulated flows would be higher than preproject flows in winter and lower than preproject flows in summer, and increased temperatures of water released from Watana in winter would affect ice formation downstream of the dam site. However, it should be pointed out that other more subtle changes brought about by regulated flows and reduced sedimentation rates could also influence the rate of plant community development and succession, as well as community structure and productivity. For example, changes in watertable elevation could affect the development of alkali soil conditions usually encountered in the early stages of floodplain colonization. These conditions are created when evaporation of groundwater brought to the surface through capillary action results in substantial accumulations of salts, especially calcium sulfate. Such conditions may affect the germination and development of various plant species, as well as the availability and cycling of plant nutrients, particularly phosphorous. During mid-successional stages, watertable elevation could be important because capillarity may supply groundwater to the tree-rooting zone, providing adequate moisture throughout the growing season, even during drought periods (Van Cleve and Viereck, 1981). The effects of such subtle changes in physical/chemical regimes cannot be reliably factored into the following discussion based on river staging, water temperatures, and ice regimes, since the influence of such changes would vary depending on river morphology and alluvium/substratum composition.

In the Watana to Devil Canyon reach, it is expected that ice formation would be precluded by the increased temperatures of outflow from Watana (Exhibit E, Vol. 5A, Chap. 2, p. E-2-125). Thus, changes in riparian zone vegetation would most likely be controlled by summer flows. Since summer flows would be reduced by comparison to preproject flows, vegetation would gradually establish on newly-exposed areas along banks and on islands. However, the actual areas involved would probably be relatively small because of the relatively steep banks in this reach. The rate of vegetative colonization on cobbled areas might be slowed by reduced sedimentation rates associated with the reduced frequency of flooding events, and the decreased sediment load of the outflow waters. With the elimination of ice scouring and major flooding events, succession of existing and newly established vegetation stands would proceed with relatively little interruption toward mature balsam poplar and white spruce forest until clearing and inundation of the Devil Canyon reservoir was begun.

In the Devil Canyon to Talkeetna reach, reduced summer flows are expected to cause river stages that are 2 to 4 ft (0.6 to 1.2 m) below preproject summer flows (Exhibit E, Vol. 5A, Chap. 2, p. E-2-106). Ice would be expected to form in this reach although its formation would likely be delayed by several weeks. The exact location of the end-of-winter ice front has not been predicted with certainty, but ice thicknesses are expected to be similar to those developed under preproject conditions (Exhibit E, Vol. 5A, Chap. 2, p. E-2-125 - E-2-126). Thus, with higher regulated winter flows, ice staging would likely be higher than it was prior to regulation. However, it is likely that ice scouring of vegetation associated with ice jams during breakup would no longer have a major effect on riparian vegetation, because (1) regulated flows would generally reduce spring flood stages and (2) the relatively warm water released from Watana would promote in-place melting (Exhibit E, Vol. 5A, Chap. 2, p. E-2-126).

Thus, above the end-of-winter ice front, vegetation development would be controlled by the same processes identified for the Watana to Devil Canyon reach. Where ice formation occurred, however, reduced summer flows would expose more area capable of being colonized, but at many locations higher ice staging associated with increased winter flows could extend into these areas, affecting not only the newly developing communities but, in some locations, even some existing vegetated areas. It is difficult to predict what effects this ice staging would have because under unregulated conditions ice staging levels are often below rather than above the water surface elevations that occur during summer flows. Thus, until clearing and inundation of the Devil Canyon reservoir was begun, the width of area occupied by early- to mid-successional stages might either increase over preproject conditions or remain similar to preproject conditions.

In the reach from Talkeetna to the Yentna River, it is impossible to predict postproject changes in vegetation with any certainty. Below the confluence of the Susitna, Chulitna, and Talkeetna rivers, the channel is braided, and the Susitna contributes only 40% of the total flow. The importance of ice processes in vegetative succession is reduced except in localized areas (R&M Consultants, 1982). The magnitude of increased winter flows would be diluted by input from the other rivers, which means any increased ice staging would be of lesser proportions than in the Devil Canyon to Talkeetna reach. Furthermore, with wide, braided channels, any increase in stage due to ice cover usually is relatively small compared to increases occurring in single or split channels (Exhibit E, Vol. 5A, Chap. 2, p. E-2-127). In this reach, spring and summer floods, through their effects on bank erosion and sediment deposition, would probably play the greatest role in vegetative development and succession. Regulated and reduced summer flows would have some effect on the frequency and severity of flooding in this reach, but the effects would be attenuated by flows from the other rivers. As a result of reduced summer flows and less frequent flooding, early- and mid-successional stands might develop sufficiently in some areas to provide some stabilization against later floods. Although reduced summer flows and perhaps increased winter flows would probably have some effect on vegetation in this reach, it is impossible to predict whether the net effects would be increases or decreases in vegetated areas or in succession/recession rates.

In the reach from the Yentna River to Cook Inlet, bankfull flows and flooding would probably be the major factors affecting vegetative succession/recession rates. In this reach flows from the Susitna (upstream of Talkeetna) contribute only 20% of the bankfull flows. Because of the dilution effect of the other rivers, as well as the tidal influence up to RM 20 (R&M Consultants, 1982), any changes in vegetation would be difficult to attribute solely to Watana operation.

Effects of Erosion, Deposition, Mesoclimatic Changes, and Increased Human Use

Vegetation is not expected to invade the drawdown zone of the impoundment (Baxter and Glaude, 1980), which typically would range in elevation from 2,095 to 2,185 ft (639 to 666 m) MSL, unless a series of drought years would prevent filling to the maximum elevations. Without a vegetative cover, the drawdown zone would remain unstable until all soil is eroded and bedrock or gravel/cobble substrates are exposed. Erosion and slumpage of soils around the shoreline of the reservoir would continue to occur because of instability and soil loss in the drawdown zone. In more severely eroded areas vegetation might be lost and many years might be required before pioneer species could become established, whereas in areas of lesser disturbance replacement of later-seral vegetative communities by earlier seres could provide valuable wildlife habitat (Wolff, 1978; Wolff and Zasada, 1979).

Permafrost thaw and subsequent erosion, slumpage, and sliding initiated by vegetation clearing for the impoundment would continue during operation (Baxter and Glaude, 1980). Much of the permafrost layer on the south side of the reservoir is within 1.8°F (1°C) of thawing (Exhibit E, Vol. 6A, Chap. 3, p. E-3-230), and once the reservoir is filled and operating the water would warm adjacent hillsides causing further permafrost melting beyond that which occurred during construction and filling. Estimates of potential acreages that could be involved have been discussed in Section J.2.1.1.1. When the area of disturbance is small, vegetation communities might be altered, reverting to earlier seral stages, but in areas of major sliding where soils are lost, the entire cycle of succession could be initiated on the melted permafrost, probably leading to wet black spruce forest or bog-type vegetation.

Deposition of sediment at the mouths of creeks entering the reservoir might eventually produce delta areas (Baxter and Glaude, 1980). These delta areas would be expected to develop vegetation in the sequence described for floodplain succession (Sec. J.1.2.2).

Tree blowdown would continue to occur during operation, primarily on the south side of the reservoir. However the extent of this damage is difficult to quantify.

The large volume of water in the reservoir would warm more slowly in spring and cool more slowly in fall than surrounding land masses. Resultant seasonal changes in air and soil temperatures near the reservoir (i.e., cooler temperatures in spring and warmer temperatures in fall) would probably affect plant phenology and perhaps cause alteration of plant communities. The south side of the reservoir might be affected the most because of prevailing northeasterly winds. The Watana reservoir would also moderate diurnal temperature fluctuations near the reservoir, and might affect local rainfall patterns and humidity (Baxter and Glaude, 1980). However, it is not possible to predict what effects these changes would have on nearby vegetation.

The reservoir could also cause increased occurrences of fog in surrounding areas, especially during breakup and freezeup periods (Baxter and Glaude, 1980). Following breakup, warm, moist air might contact the cold water of the reservoir, creating persistent fog banks. Prior to freezeup, cold air contacting warm water in the reservoir would create ice fog conditions, which might cause rime ice accumulations on vegetation. When accumulations are thick, branches and twigs can break, damaging vegetation. However, if plants are not severely damaged, this could have a beneficial effect for wildlife if succulent new growth is induced. Similarly, ice fogging and rime ice accumulation would be expected to occur along the downstream floodplain in the section of the river where ice formation is prevented by Watana outflow temperatures.

Impacts associated with increased human use of the area during construction and filling would continue during operation, although perhaps to a lesser extent. Operational personnel and their families would be fewer in number than construction personnel. Although the Applicant has proposed measures to mitigate the impacts of increased human use, increased fire incidence and ORV/ATV usage could still occur with some frequency and would consequently have some effect. However, more extensive impacts of this nature might be expected to occur as a result of more extensive use of the area by the general public as discussed in Section J.2.1.3. The potential impacts of fire and ORV/ATV use have been discussed previously in Section J.2.1.1.1.

J.2.1.2 Devil Canyon Development

J.2.1.2.1 Construction

Construction of the Devil Canyon development would result in impacts to terrestrial plant communities and wetlands of a similar nature to those described for the Watana development. However, the extent of the impacts associated with Devil Canyon, as described below, are generally expected to be less than for Watana.

Vegetation Removal

Construction and filling of the Devil Canyon development would result in removal of approximately 7,100 acres (2,800 ha) of vegetation from the upper and middle Susitna Basin. Vegetation covering approximately 5,900 acres (2,400 ha) of this area would be permanently lost due to construction of the dam, spillways, and impoundment. Clearing for the construction camp and village, construction roads, contractor work areas, and borrow areas would remove about 1,200 acres (490 ha) of vegetation. As with the temporary Watana facilities, the potential for vegetation establishment and growth on the latter areas would only be temporarily lost because these facilities would only be required during construction.

The area of vegetation that would be permanently lost represents about 0.2% of all the vegetation within the entire upper and middle Susitna Basin above Gold Creek (Table J-22). About 97% of the vegetation lost would be forest types and almost half of these forests would be mixed conifer-deciduous types. Although open mixed forest stands that would be removed by construction of the Devil Canyon facility represent only about 1% of that type within the upper and middle Susitna Basin, almost 5% of the closed mixed forest stands in the upper and middle Susitna Basin would be permanently lost. As discussed in Section J.2.1.1.1, the occurrence of birch forest types in small, scattered stands causes the proportion of these types that would be lost, as presented in Table J-22, to be overestimated because of the mapping scales used. If it is assumed that birch stands are usually found on relatively warm slopes near rivers (see Sec. J.1.2.1.1), the proportion of birch forest types that might be lost may be estimated more reliably on the basis of the area of birch forest mapped (at a scale of 1:63,360) within 10 mi (16 km) of the Susitna River between Gold Creek and the Tyone River (Table J-8). Using these estimates for the area within 10 mi (16 km) of the river, about 4% of the open birch forests and about 19% of the closed birch forests would be permanently lost. However, the actual proportions of open and closed birch forest that would be removed from the upper and middle Basin are probably somewhere between 2 to 4% and 10 to 19%, respectively.

The area that would be cleared for temporary facilities and borrow areas amounts to only 0.03% of the vegetation in the entire upper and middle Susitna Basin (Table J-23). Over 90% of this area presently supports forest types, principally open black spruce and closed mixed forests. According to the schedule presented in Exhibit E (Vol. 6A, Chap. 3, p. E-3-277 - E-3-278), temporary facilities and borrow areas would be removed and/or regraded and rehabilitated by the end of the construction and reservoir-filling period (within nine years of the start of construction). General rehabilitation procedures planned by the Applicant have been described in Section J.3.1.3 and Exhibit E (Vol. 6A, Chap. 3, p. E-3-279 - E-3-281).

The discussion concerning reestablishment and succession of vegetation following physical rehabilitation of construction facilities presented in Section J.2.1.1.1 for the Watana development is applicable to the Devil Canyon development also. However, vegetation reestablishment on disturbed areas located on steep slopes would probably take more time than for sites with more gentle grades. With steep slopes natural revegetation might be slowed or hampered by soil erosion, but use of introduced or perhaps even native grass species to establish a quick cover and minimize erosion might inhibit later invasion by other native species (Johnson, 1981; Johnson, 1982).

As explained in Section J.2.1.1.1, extremely liberal estimates of wetlands that could be lost due to construction of the Devil Canyon development (Tables J-24 and J-25) have been made on the basis of the Viereck and Dyrness (1980) vegetation classification system (see Table J-5). The areas presented in Tables J-24 and J-25 really represent areas that would be lost in which wetlands potentially could occur.

Table J-22. Acreage of Vegetation Types that Would be Permanently Lost as a Result of the Devil Canyon Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

	Vegetated Area Lost (acres)†[1]			
Vegetation Type	Dam and Spillways	Impoundment	Total	Percentage of Basin Total for Respective Type†[2]
Forest	40	5,700	5,700	0.7
Woodland black spruce		330	330	0.08
Woodland white spruce		49	49	
Open black spruce	10	740	750	0.5
Open white spruce		810	810	
Open birch		140	140	7.0†[3]
Closed birch	7	1,100	1,100	110.0†[3]
Open balsam poplar		15	15	†[4]
Closed balsam poplar		20	20	†[4]
Open mixed	17	690	710	1.2
Closed mixed	5	1,800	1,800	4.6
Tundra	0	27	27	<0.01
Wet sedge-grass		27	27	0.2
Shrubland	0	170	170	0.01
Open tall shrub		5	5	<0.01
Closed tall shrub		2	2	
Birch shrub		120	120	0.1
Willow shrub		35	35	0.1
Mixed low shrub		10	10	<0.01
Unvegetated	5	2,000	2,000	0.3
Rock		37	37	0.01
River	2	2,000	2,000	5.6
Lake	2	2	5	0.01
Total Vegetated Area	40	5,900	5,900	0.2
Total Area	44	7,900†[5]	7,900	0.2

†[1] Acreages converted from hectares as given in the source and rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-7.

†[3] This is an overestimation caused by differences in mapping scales (see text).

†[4] These vegetation types were not quantified in Table J-7 (see text).

†[5] The total area that would be inundated by the Devil Canyon impoundment as calculated by McKendrick et al. (1982) in the vegetation studies differs slightly from the impoundment area stated in Section 2.1.2.2. This is probably due to differences in mapping techniques.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.84 (Revised), p. 3B-7-5, which is based on the 1:63,360 maps (Fig. J-2).

Table J-23. Acreage of Vegetation Types that Would be Temporarily Lost and Would Require Rehabilitation as a Result of the Devil Canyon Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin†[1]

	Vegetated Area Lost (acres)†[2]						
			Borrow Areas				
Vegetation Type	Construction Camp	Construction Village	G	K†[3]	Contractor Work Areas and Construction Roads†[3]	Total	Percentage of Basin Total for Respective Type†[4]
Forest	89	96	47	290	580	1,100	0.1
Woodland black spruce			30			30	0.01
Open black spruce			12	27	310	350	0.1
Closed birch					23	23	2.3
Open mixed					100	100	0.2
Closed mixed	89	96	5	270	150	600	1.5
Tundra	0	0	0	0	0	0	0
Shrubland	0	0	7	44	0	52	<0.01
Open tall shrub			7			7	<0.01
Birch shrub				44		44	0.05
Unvegetated	0	0	0	27	0	27	<0.01
Lake				27		27	0.04
Total Vegetated Area	89	96	54	340	580	1,200	0.03
Total Area	89	96	54	370	580	1,200	0.03

†[1] The use of the word, temporarily, implies that the area would eventually be rehabilitated.

†[2] Acreages converted from hectares as given in the source and rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[3] Values estimated by determining total acreages within 10 mi (16 km) of the Susitna River (Table J-8) of types that might be affected (according to Exhibit E, Vol. 6A, Chap. 3, p. E-3-276), and determining what proportion each type represents of the total for all types affected. These proportions were then multiplied by the expected acreage of borrow site K or the estimated total acreage of work areas and roads to give estimates of each type that might be affected.

†[4] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-7.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.84 (Revised), p. 3B-7-5, which is based on the 1:63,360 maps (Fig. J-2).

Table J-24. Acreage of Potential Wetland Types that Would be Permanently Lost as a Result of the Devil Canyon Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

Wetland Type	Potential Wetland Area Lost (acres)†[1] Dam and Spillways	Impoundment	Total	Percentage of Basin Total for Respective Type†[2]
Palustrine forested, needle-leaved evergreen	10	1,900	1,900	0.3
Palustrine forested, broad-leaved deciduous	0	35	35	3.5
Palustrine scrub-shrub, broad-leaved deciduous	0	170	170	0.01
Palustrine or lacustrine emergent, persistent	0	27	27	0.2
Lacustrine	2	2	5	0.01
Riverine	2	2,000	2,000	5.6
Total Potential Wetland Area	15	4,200	4,200	0.2

†[1] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, converted from hectares as given in the source, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-12.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-22 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Table J-25. Acreage of Potential Wetland Types that Would Be Temporarily Lost and Would Require Rehabilitation as a Result of the Devil Canyon Development and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin†[1]

Wetland Type	Potential Wetland Areas Lost (acres)†[2]					Percentage of Basin Total for Respective Type†[4]
	Construction Camp and Village	Borrow Areas G	Borrow Areas K†[3]	Contractor Work Areas and Construction Roads†[3]	Total	
Palustrine forested, needle-leaved evergreen	0	42	27	310	380	0.05
Palustrine scrub-shrub, broad-leaved deciduous	0	0	44	0	44	<0.01
Palustrine or lacustrine emergent, persistent	0	0	0	0	0	0
Lacustrine	0	0	27	0	27	0.04
Riverine	0	0	0	0	0	0
Total Potential Wetland Area	0	42	99	310	450	0.02

†[1] The use of the word, temporarily, implies that the area would eventually be rehabilitated.

†[2] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, converted from hectares as given in the source, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[3] See footnote †[3] in Table J-23.

†[4] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-12.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-23 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Thus, as a liberal estimate, 4,200 acres (1,700 ha) or about 0.2% of the potential wetlands in the upper and middle Susitna Basin would be permanently lost as a result of construction and filling of the Devil Canyon dam, spillways, and impoundment (Table J-24). An additional 450 acres (180 ha) of potential wetland types would be affected by construction of temporary facilities and excavation of borrow areas (Table J-25). This latter acreage represents only 0.02% of the potential wetlands in the upper and middle Susitna Basin. Almost half of the area that would be permanently removed is riverine wetland. The palustrine forested, needle-leaved evergreen type comprises most of the rest of the wetland that would be permanently removed and over 80% of the wetland that would be affected by temporary facilities. Although the land areas where temporary facilities had been located would be physically rehabilitated, it is impossible to predict whether wetlands that originally occurred in these areas would be restored (see Sec. J.2.1.1.1).

Indirect Vegetation Loss or Damage and Alteration of Plant Communities

Vegetation loss or damage and alteration of plant communities could occur as a result of rock slides and erosion on the steep slopes surrounding the impoundment. Unlike the Watana impoundment, areas of permafrost are relatively sparse on the rocky slopes surrounding the proposed Devil Canyon impoundment. Thus, erosion, slides, thawing of permafrost, and subsequent effects on vegetation (as described in Sec. J.2.1.1.1) would be much less in comparison to Watana. Although the areal extent of slope instability along the Devil Canyon reservoir shoreline cannot be reliably quantified in advance, the Applicant has calculated, on the basis of aerial photographic interpretation and limited field reconnaissance, that about 2,500 acres (1,000 ha) of land adjacent to the reservoir shoreline might be affected to some degree by beaching and to a much lesser extent by flow or block slides (Supplemental Information to Exhibit E, Vol. 7, Chap. 6, Item 7). It is anticipated that these slope failures would be a long-term, progressive activity initiated during construction and continuing during operation, and that some portion of these areas would be susceptible to erosion and loss of vegetation.

Tree blowdown and fugitive dusting impacts might occur during Devil Canyon construction, but the magnitude of the impacts should be less than for Watana. In the case of tree blowdown, the maximum fetch would be less at the Devil Canyon site than at Watana. Fugitive dusting would be less because of the smaller size of dust-generating areas such as the cleared impoundment zone, borrow sites, and construction roads.

The effects of altered drainage caused by construction activities have been discussed in Section J.2.1.1.1 for the Watana development. Similar effects might occur during Devil Canyon construction although impacts would be less extensive than at Watana due to the steep slopes, sparse permafrost conditions, and generally smaller scope of activities at Devil Canyon.

The effects of increased human activity (i.e., increased fire incidence, ORV/ATV usage, and nonessential disturbances of vegetation) described for the Watana development (see Sec. J.2.1.1.1) would also occur at the Devil Canyon development. However, the effects should be less than for Watana because of the smaller work force and shorter construction time.

J.2.1.2.2 Operation

Impacts resulting from operation of the Devil Canyon facility would be similar in nature to those caused by Watana operation. As with construction-related impacts, however, many of the impacts associated with Devil Canyon would be generally less extensive than for Watana.

The effects of regulated flows on riparian plant communities downstream of Talkeetna would be similar to those described in Section J.2.1.1.2 for operation of Watana alone. Since increased water temperatures associated with reservoir outflow would extend further downstream with Devil Canyon in operation, more in-place melting of ice during breakup would occur downstream of Talkeetna. Thus, the somewhat localized effects of ice jamming would probably be reduced slightly over Watana only conditions for some distance below Talkeetna.

With Devil Canyon in operation, the factors controlling riparian vegetation in the Devil Canyon to Talkeetna reach would change. Ice formation would be considered unlikely in this reach (Exhibit E, Vol. 5A, Chap. 2, p.E-2-169), and vegetation development would probably be controlled by summer flows. Since summer flows would be reduced by comparison to preproject flows and since ice-staging effects associated with operation of Watana alone would be eliminated, an increase in vegetated area over preproject conditions would probably occur. The width of area occupied by early- to mid-successional stages would probably increase over preproject conditions initially. With time, however, the regulated flows and decreased incidence of flooding would allow succession to proceed towards mature balsam poplar and white spruce forests. The width of area occupied by early- to mid-successional stages might eventually be decreased below preproject conditions since fewer events capable of causing vegetative recession to earlier seral stages would occur.

The drawdown zone of the Devil Canyon impoundment would typically range in elevation from 1,405 to 1,455 ft (429 to 444 m) MSL. There is little probability of vegetation establishment within the drawdown zone since the water level would only be lowered significantly during August and September (Exhibit E, Vol. 5A, Chap. 2, p.E-2-155). Changes in plant communities associated with reservoir-induced changes in soil water tables are expected to be minimal because of the greater prevalence of consolidated, rocky substrata in the Devil Canyon area.

In general, erosion-caused vegetation loss or alteration would be less extensive than for the Watana impoundment, due to the infrequency of permafrost conditions and the more stable slope conditions in the Devil Canyon area (see Secs. E.2.1.1 and E.2.1.2, Reservoir Slope Instability, in App. E). However, those erosion processes initiated following impoundment clearing (see Sec. J.2.1.2.1) would probably continue during operation. Estimates of potential acreages that could be involved have been discussed in Section J.2.1.2.1. If the old landslide at RM 175 moves after filling (Sec. E.2.1.2.1, Regional Seismicity, in App. E), somewhat temporary flooding of upstream areas might occur, which could cause some unpredictable vegetation loss. Areas likely to be affected include the mouths and floodplains of Fog and Tsusena Creeks.

Mesoclimatic effects described for the Watana development (Sec. J.2.1.1.2) -- such as tree blowdown, alteration of air and soil temperature, fog, and rime ice accumulations near the reservoir and in the downstream floodplain -- might also occur as a result of Devil Canyon operation. However, the extent of the effects, with the exception of downstream floodplain fog and icing, would be much less than for Watana because of the smaller size and the physical configuration of the Devil Canyon reservoir.

Once Devil Canyon is in operation, impacts to vegetation associated with increased use of the area by operational personnel would be minimal because of the small numbers of people involved. However, increased use of the area by the general public as discussed in Section J.2.1.3 could have a greater impact on vegetation.

J.2.1.3 Access Routes

J.2.1.3.1 Denali Highway to Watana

Construction

Construction of the Denali Highway-to-Watana access road would result in clearing and permanent loss of about 630 acres (250 ha) of vegetation (Table J-26). This area amounts to 0.02% of the vegetation within the upper and middle Susitna Basin. Over 70% of the vegetation removed would be low shrub types and almost 25% would be tundra types.

The proposed access route alignment has been adjusted by the Applicant to avoid important wetland areas near Deadman and Tsusena creeks and to minimize crossage of other wetland areas. However, about 480 acres (190 ha) of potential wetland types, primarily the palustrine scrub-shrub, broad-leaved deciduous type, might be cleared for the Denali Highway-to-Watana access road (Table J-27). As explained in Section J.2.1.1.1, the areas in Table J-27 are extremely liberal estimates based on correlation to the Viereck and Dyrness (1980) vegetation classification system (see Table J-5).

Temporary loss of vegetation might occur as a result of construction-related vehicle movements outside the actual access route alignment and clearing for possible borrow areas. The Applicant has proposed construction methods to reduce requirements for fill material (Exhibit E, Vol. 6A, Chap. 3, p. E-3-264 - E-3-266). However, nine borrow areas that might be used on a contingency basis have been identified along the Denali Highway-to-Watana route. The Applicant has indicated that these borrow sites would be excavated to about 8 ft (2.5 m) on the average and that each would cover from 10 to 20 acres (4 to 8 ha). Additional area would be required for overburden and soil storage during excavation. Thus, in a worst-case situation, about 200 acres (81 ha) of mostly shrub and tundra vegetation types would be temporarily removed during borrow excavation. These sites would be physically rehabilitated following construction and vegetation reestablishment should proceed as described in Section J.2.1.1.1. Since the length of soil storage times would be considerably shorter than those associated with rehabilitation efforts for Watana and Devil Canyon facilities, vegetation recolonization might be initiated sooner and proceed more rapidly than for dam site facilities.

Indirect effects to vegetation might occur as a result of fugitive dusting, erosion, and altered drainage patterns. Refer to Section J.2.1.1.1 for a discussion of these effects.

Operation

Vegetation would continue to be affected by use of the access road during operation. Dust- and erosion-related impacts to bordering vegetation would continue. The access road would facilitate increased human use of the area, which would increase the frequency and extent of disturbances such as ORV/ATV use and human-caused fires. Human-related impacts to vegetation could likely increase if general public usage of the area increases following the completion of construction at the Watana and Devil Canyon developments.

Table J-26. Acreage of Vegetation Types that Would Be Cleared for Access and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

	Vegetated Area Cleared (acres) and Percentage of Basin Total for Respective Type†[1-3]							
	Denali Highway to Watana Road		Watana to Devil Canyon Road		Rail Access to Devil Canyon		Total for All Access Routes	
Vegetation Type	acres	%	acres	%	acres	%	acres	%
Forest	28	<0.01	93	0.01	70	0.01	190	0.02
Woodland black spruce	4	<0.01					4	<0.01
Woodland white spruce			14	<0.01			14	
Open black spruce			1	0.01	4	<0.01	5	0.02
Open white spruce	2	<0.01	39				41	
Open birch					2	0.1	2	0.1
Closed birch			2	0.2			2	0.2
Closed balsam poplar					1	†[4]	1	†[4]
Open mixed	22	0.04	10	0.02	14	0.02	46	0.08
Closed mixed			26	0.07	50	0.1	76	0.2
Tundra	150	0.02	53	0.01	2	<0.01	210	0.02
Wet sedge-grass	31	0.3	11	0.09	2	0.02	43	0.4
Mesic sedge-grass	44	0.01					44	0.01
Sedge-shrub			19	†[3]			19	†[4]
Mat and cushion	79	0.05	24	0.01			100	0.06
Shrubland	450	0.03	260	0.02	0	0	700	0.04
Open tall shrub			20	0.02			20	0.02
Closed tall shrub			55				55	
Birch shrub	200	0.2	110	0.1			310	0.4
Willow shrub	200	0.8	13	0.05			220	0.8
Mixed low shrub	51	<0.01	59	0.01			110	0.01
Rock	2	<0.01	0	0	0	0	2	<0.01
Total Vegetated Area	630	0.02	400	0.01	72	<0.01	1,100	0.03

†[1] Acreages rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-7.

†[3] Additional acreages would be cleared for construction of the railhead facility at Devil Canyon and for contigency borrow sites (see text).

†[4] These vegetation types were not quantified in Table J-7 (see text).

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.85 (Revised), p. 3B-7-6, which is based on mapping at the 1:63,360 scale.

Table J-27. Acreage of Potential Wetland Types that Would Be Cleared for Access and Comparison of each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

	Potential Wetland Area Cleared (acres) and Percentage of Basin Total for Respective Type†[1,2]							
	Denali Highway to Watana Road		Watana to Devil Canyon Road		Rail Access to Devil Canyon		Total for All Access Routes	
Wetland Type	acres	%	acres	%	acres	%	acres	%
Palustrine forested, needle-leaved evergreen	6	<0.01	55	0.01	4	<0.01	64	0.01
Palustrine forested, broad-leaved deciduous	0	0	0	0	1	0.1	1	0.1
Palustrine scrub-shrub, broad-leaved deciduous	450	0.04	180	0.01	0	0	630	0.05
Palustrine or lacustrine emergent, persistent	31	0.3	11	0.09	2	0.02	43	0.4
Lacustrine	0	0	0	0	0	0	0	0
Riverine	0	0	0	0	0	0	0	0
Total Potential Wetland Area	480	0.02	250	0.01	6	<0.01	740	0.03

†[1] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-12.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-26 using correlations of vegetation types to potential wetland classes as given in Table J-5.

J.2.1.3.2 Watana to Devil Canyon

Construction

About 400 acres (160 ha) of vegetation would be cleared and permanently lost as a result of access road construction between Watana and Devil Canyon (Table J-26). This area represents 0.01% of the vegetation within the entire upper and middle Susitna Basin and 0.04% of the vegetation within 10 mi (16 km) of the Susitna River. Most of the vegetation removed (64%) would be shrub types. Forest and tundra types comprise 23% and 13%, respectively, of the vegetation that would be lost.

The proposed access route alignment has been adjusted by the Applicant to avoid important wetland areas near Jack Long Creek and to minimize crossage of other wetland areas. Over 60% [250 acres (100 ha)] of the vegetation cleared for the Watana-to-Devil Canyon access road might potentially be wetland (Table J-27). As explained in Section J.2.1.1.1, the areas of potential wetlands in Table J-27 are extremely liberal estimates which are based on correlations to the Viereck and Dyrness (1980) vegetation classification system (see Table J-5).

Temporary loss of vegetation caused by construction-related activity outside the actual access route could occur. Clearing as well as storage of overburden and soil associated with borrow site excavation might also result in temporary loss of vegetation. Five potential borrow sites similar in size to those described in Section J.2.1.3.1 have been identified for contingency use. Thus, in a worst-case situation about 110 acres (45 ha) of vegetation would be temporarily removed for fill material excavation. Rehabilitation of these types of disturbances has been described in Section J.2.1.3.1.

Indirect effects to vegetation might occur as a result of fugitive dusting, erosion, and altered drainage patterns. Refer to Section J.2.1.1.1 for a discussion of these effects.

Operation

Refer to Section J.2.1.3.1 for a discussion of the operational impacts of the Watana-to-Devil Canyon access road.

J.2.1.3.3 Rail Access to Devil Canyon

Construction

Construction of the rail spur between Gold Creek and Devil Canyon would result in the removal and permanent loss of about 70 acres (30 ha) of vegetation consisting mostly of forest types, primarily closed mixed conifer-deciduous forest (Table J-26). Clearing would remove less than 0.01% of the total vegetation and 0.1% of the closed mixed and open birch forest types within the upper and middle Susitna Basin. About 50 acres (20 ha) of vegetation would also be removed to construct the railhead facility.

The proposed access route alignment and location of the railhead facility have been selected by the Applicant to avoid important wetland areas near Jack Long Creek and to minimize crossage of other wetland areas. In fact, only 6 acres (2.5 ha) of potential wetland types may need to be cleared for the rail access to Devil Canyon (Table J-27). As explained in Section J.2.1.1.1, the areas of potential wetlands in Table J-27 are extremely liberal estimates which are based on correlations to the Viereck and Dyrness (1980) vegetation classification system (see Table J-5).

Temporary loss of vegetation caused by construction-related activity outside the actual access route might occur. Rehabilitation of this type of disturbance has been described in Section J.2.1.3.1.

Operation

Impacts to vegetation resulting from usage of rail access would will be minimal. Most of the impacts of using the access roads (see Sec. J.2.1.3.1) might also occur along the rail access route but the frequency and extent of occurrence would be greatly reduced by comparison to road access.

J.2.1.4 Power Transmission Facilities

J.2.1.4.1 Dams-to-Gold Creek Segment

Construction

The 300 ft-wide (91 m-wide) right-of-way for the Watana-to-Gold Creek transmission line proposed for Watana only operation would cross approximately 1,300 acres (530 ha) of vegetation (Table J-28). This area represents a worst-case estimate of vegetation that would be impacted, since only the forest and tall shrub types would require major clearing. Between Watana and Devil Canyon most of the vegetation in the proposed right-of-way is shrub and tundra types. Less than 5% of the proposed right-of-way is occupied by forest types. In contrast, from Devil Canyon to Gold Creek the proposed right-of-way is over 90% forested with closed mixed conifer-deciduous forest being the most prevalent type. The only other vegetation type that would be crossed is wet sedge-grass tundra.

The Applicant has indicated that site-specific adjustments would be made in the transmission line corridors during detailed alignment studies to minimize wetland and floodplain crossings (Exhibit E, Vol. 6A, Chap. 3, p. E-3-290). However, a worst-case estimate of potential wetland types that would be crossed by the Watana-to-Gold Creek transmission line during Watana only operation is presented in Table J-29. Of the approximately 550 acres (220 ha) of potential wetland that would be crossed, almost all of the section between Watana and Devil Canyon is palustrine scrub-shrub, broad-leaved deciduous; whereas, palustrine forested, needle-leaved evergreen; palustrine or lacustrine emergent, persistent; and a small area of riverine types would be crossed by the section between Devil Canyon and Gold Creek. With the exception of the palustrine or lacustrine emergent, persistent type, the area of each wetland type that would be crossed represents less than 0.1% of the respective type within the upper and middle Susitna Basin.

Once Devil Canyon is operational, two additional lines would be added between Devil Canyon and Gold Creek requiring a widening of the Devil Canyon-to-Gold Creek right-of-way to 510 ft (155 m). The additional proposed right-of-way would cross about 210 acres (85 ha) of the same vegetation types and about 47 acres (19 ha) of the same potential wetland types as those that would be crossed by the initial Devil Canyon-to-Gold Creek right-of-way segment (Tables J-28 and J-29).

The Applicant has indicated that limited cutting of trees and shrub vegetation would be required for line-of-site staking and distance measurement during surveying to locate centerlines. Clearing of vegetation from the rights-of-way would be selective, with total removal generally

Table J-28. Acreage of Vegetation Types that Would Be Crossed by Transmission Corridors from the Dams to Gold Creek and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

	Vegetated Area Crossed (acres) and Percentage of Basin Total for Respective Type†[1,2]							
	Watana Only				Devil Canyon Addition			
	Watana to Devil Canyon		Devil Canyon to Gold Creek		Devil Canyon to Gold Creek		Total Dams to Gold Creek	
Vegetation Type	acres	%	acres	%	acres	%	acres	%
Forest	42	0.01	270	0.03	190	0.02	510	0.06
Woodland black spruce	3	0.01					3	0.02
Woodland white spruce	22		36	0.01	25	0.01	82	
Open black spruce			6	<0.01	4	<0.01	10	<0.01
Open birch			4	0.2	3	0.2	7	0.4
Closed birch			7	0.7	5	0.5	12	1.2
Closed mixed	22	0.06	220	0.6	150	0.4	390	1.0
Tundra	270	0.03	23	<0.01	16	<0.01	310	0.03
Wet sedge-grass			23	0.2	16	0.1	39	0.3
Mesic sedge-grass	7	<0.01					7	<0.01
Sedge-shrub	130	†[3]					130	†[3]
Mat and cushion	130	0.08					130	0.08
Shrubland	720	0.05	0	0	0	0	720	0.05
Open tall shrub	100	0.08					100	0.08
Closed tall shrub	160						160	
Birch shrub	260	0.3					260	0.3
Willow shrub	33	0.1					33	0.1
Mixed low shrub	160	0.01					160	0.01
Total Vegetated Area	1,000	0.03	290	0.01	210	0.01	1,500	0.04

†[1] Acreages rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-7.

†[3] These vegetation types were not quantified in Table J-7 (see text).

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.80 (Revised), p. 3B-7-3, which is based on mapping at the 1:63,360 scale.

Table J-29. Acreage of Potential Wetland Types that Would Be Crossed by Transmission Corridors from the Dams to Gold Creek and Comparison of Each Type with the Total Acreage of that Type in the Upper and Middle Susitna Basin

	Potential Wetland Area Crossed (Acres) and Percentage of Basin Total for Respective Type†[1,2]							
	Watana Only				Devil Canyon Addition			
	Watana to Devil Canyon		Devil Canyon to Gold Creek		Devil Canyon to Gold Creek		Total Dams to Gold Creek	
Wetland Type	acres	%	acres	%	acres	%	acres	%
Palustrine forested, needle-leaved evergreen	24	<0.01	41	0.01	29	<0.01	95	0.01
Palustrine scrub-shrub, broad-leaved deciduous	460	0.04	0	0	0	0	460	0.04
Palustrine or lacustrine emergent, persistent	0	0	23	0.2	16	0.1	39	0.3
Lacustrine	0	0	0	0	0	0	0	0
Riverine	0	0	3†[3]	0.01	2†[3]	0.01	5†[3]	0.01
Total Potential Wetland Area	480	0.02	67	<0.01	47	<0.01	590	0.03

†[1] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-12.

†[3] From Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, p. 3B-12-8.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-28 using correlations of vegetation types to potential wetland classes as given in Table J-5.

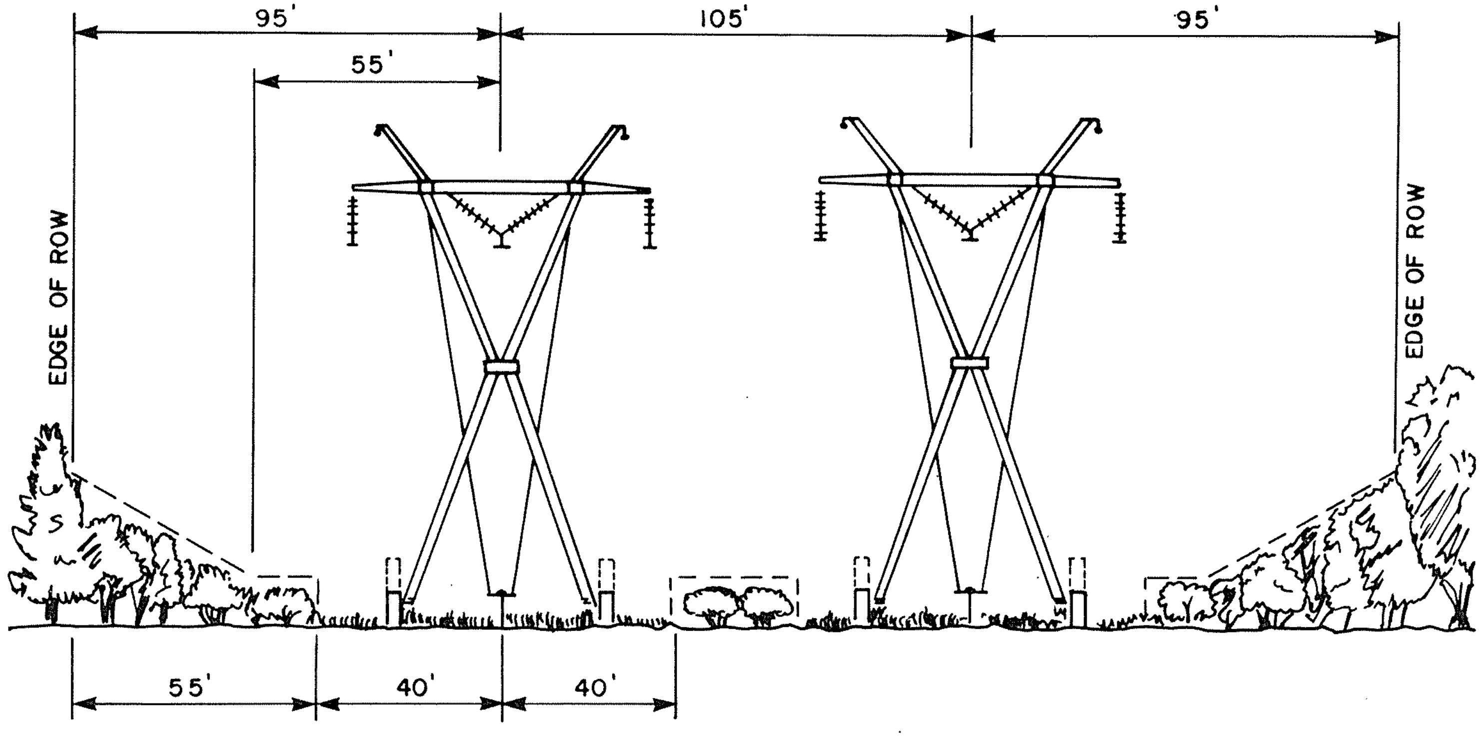
being confined to tower sites, access trails, and temporary construction facilities. Herbicides would not be used. Typical clearing limits for guyed X-type towers up to 85 ft (26 m) tall on level terrain are illustrated in Figure J-6. Vegetation would be cleared to various maximum heights depending upon distance from the lines, but, generally, at least ground layer vegetation would be left intact. Outside the rights-of-way, additional limited clearing would be required for access trails and to remove danger trees (trees outside the right-of-way which are tall enough to contact the towers, guys, or lines if they were to fall) (Exhibit E, Vol. 6A, Chap. 3, p. E-3-270 - E-3-271).

Thus, forest and tall shrub types, because of their heights, are the vegetation types that, generally, would be most impacted by clearing of the rights-of-way. Between Watana and Gold Creek, forest and tall shrub types represent 44% of the vegetation in the right-of-way during Watana only operation and 51% of the vegetation if the Devil Canyon-to-Gold Creek segment is widened for two-dam operation.

Removal of trees on permafrost areas, even when understory vegetation is left intact can result in permafrost thaw and subsidence potentially causing damage to vegetation and alteration of plant communities (Van Cleve, 1978). In addition, construction-related movements and activities in and around the rights-of-way and access trails might cause localized erosion and permafrost thaw and subsequent damage to vegetation. Erosion- and permafrost-related impacts would be minimized, however, by the use of balloon-tire and flat-tread vehicles. These types of impacts are likely to be greater in tundra types and wet areas.

Operation

After transmission line construction is complete, vegetation succession would proceed in disturbed areas as described in Section J.1.2.1. Resprouting and new growth following construction disturbances should provide enhanced browse for wildlife in many areas (see Sec. J.2.1.1.1).



NOTE:

TOWER SPACING CENTERLINE TO CENTERLINE DISTANCE 105'.

TOWER SPACING CENTERLINE TO EDGE OF RIGHT-OF-WAY 95'.

NUMBER TOWERS	RIGHT-OF-WAY WIDTH
1	190 FEET
2	300 FEET
3	400 FEET
4	510 FEET

Figure J-6. Typical Transmission Right-of-Way Cross Section.
[Source: Exhibit E, Vol. 6B, Chap. 3, Fig. E.3.85]

The Applicant expects that routine maintenance-related clearing of the rights-of-way would be necessary about every ten years (Exhibit E, Vol. 6A, Chap. 3, p. E-3-272). Clearing might occur more frequently if necessary for tower or line repair or maintenance. No herbicides would be used. Selective clearing by manual clipping and trimming should continue to stimulate browse production of willow and other browse species. Other shrubs such as crowberry and Labrador tea may suffer increased mortality if rhizomes or roots are damaged during clearing (Hernandez, 1973; Chapin and Shaver, 1981). On the other hand, if moose and other wildlife are attracted to the rights-of-way because of increased browse production, over-browsing could affect future vegetative production or plant community structure. However, the potentially greatest impacts to vegetation during the operational phase might be caused by ORV/ATV usage in the rights-of-way (see Sec. J.2.1.1.1).

J.2.1.4.2 Healy-to-Willow Segment

Construction

The vegetation type classifications used in mapping the Healy-to-Willow segment are different from those used for the rest of the proposed project, necessitating that the impacts of this segment be discussed separately from the other segments (see Sec. J.1.2.3.2). Approximately 4,600 acres (1,900 ha) of vegetation would be crossed by the Susitna addition to the existing Healy-to-Willow intertie right-of-way (Table J-30). From Gold Creek to Healy the addition would be 190 ft (58 m) wide, and from Gold Creek to Willow the addition would be 290 ft (88 m) wide. The area of 4,600 acres (1,900 ha) represents a worst-case estimate of vegetated area that would be impacted. Major vegetation types that would be crossed are upland spruce-hardwood forest, shrublands, and to a lesser extent lowland spruce-hardwood forest. Due to their height, forest and tall shrub types, which represent about 50% of the right-of-way, would be the vegetation types most impacted by clearing of the right-of-way.

As a worst-case estimate, the Healy-to-Willow segment would cross about 3,300 acres (1,300 ha) of potential wetland types (Table J-31). This area represents about 70% of the area within the proposed Healy-to-Willow right-of-way. Palustrine scrub-shrub, broad-leaved deciduous wetland would be the most prevalent wetland type crossed. However, the Applicant has indicated that site-specific adjustments would be made in the transmission line corridor during detailed alignment studies in order to minimize wetland and floodplain crossings (Exhibit E, Vol. 6A, Chap. 3, p. E-3-290).

Additional construction impacts are discussed in Section J.2.1.4.1.

Operation

Operational-phase impacts to vegetation are discussed in Section J.2.1.4.1.

J.2.1.4.3 Healy-to-Fairbanks Segment

Construction

The 300 ft-wide (91 m-wide) proposed right-of-way from Healy to Fairbanks would cross approximately 3,500 acres (1,400 ha) of vegetation (Table J-32). This area represents a worst-case estimate of the vegetation that would be impacted. The majority of the proposed right-of-way is covered by forest, although relatively large areas of low shrubland and wet sedge-grass are also present. Open spruce is the most common forest type. The forest and tall shrub types occupy about 74% of the vegetated area within the proposed right-of-way and are likely to be more impacted by clearing than other vegetation types due to their height.

A worst-case estimate of potential wetland types that would be crossed by the Healy-to-Fairbanks transmission line segment is presented in Table J-33. About 2,700 acres (1,100 ha), or approximately 1.7% of the potential wetland area within the Healy-to-Fairbanks transmission corridor study area (see Table J-16) would be crossed. Most of the potential wetland area is palustrine forested, needle-leaved evergreen or a complex of palustrine forested, scrub-shrub, and emergent types. However, about 4% of the palustrine or lacustrine emergent, persistent wetlands in the transmission corridor study area would be crossed by the proposed right-of-way. The Applicant has indicated that site-specific adjustments would be made in the transmission line corridor during detailed alignment studies in order to minimize wetland and floodplain crossings (Exhibit E, Vol. 6A, Chap. 3, p. E-3-290).

Additional construction-related impacts are discussed in Section J.2.1.4.1.

Operation

Operational-phase impacts to vegetation would be the same as discussed in Section J.2.1.4.1.

Table J-30. Acreage of Vegetation Types that Would be Crossed by the Healy-to-Willow Transmission Corridor and Percentage of Each Type within the Proposed Transmission Corridor

Vegetation Type	Vegetated Area Crossed (acres)†1,2			Percentage of Transmission Corridor
	Gold Creek to Healy	Gold Creek To Willow	Total	
Upland spruce-hardwood forest	690	370	1,100	23.9
Lowland spruce-hardwood forest	0	830	830	18.0
Bottomland spruce-poplar forest	15	330	340	7.4
Wet tundra	270	0	270	5.9
Moist tundra	0	220	220	4.8
Alpine tundra	44	21	65	1.4
Shrublands	1,000	260	1,300	28.3
Low brush, Muskeg bog	0	530	530	11.5
Total Vegetated Area	2,000	2,600	4,600	100

†1 Calculated from data and maps in Commonwealth Associates (1982). The values presented here represent the additional clearing of the corridor from the 110 ft (34 m) given by Commonwealth Associates (1982) to a total width of 300 ft (91 m) from Gold Creek to Healy and 400 ft (122 m) from Gold Creek to Willow. Thus, the areas presented in this table represent areas that would be cleared within a 190-ft (58-m) wide corridor from Gold Creek to Healy and a 290-ft (88-m) wide corridor from Gold Creek to Willow.

†2 Acreages rounded to two significant figures; values do not add up to totals due to rounding errors.

Conversion: To convert from acres to hectares, multiply by 0.405.

Source: Modified from revisions to Supplemental Information to Exhibit E, Table E.3.79 (Revised), p. 3B-7-2, as presented in the Applicant's Responses to the Department of the Interior Comments on License Application, February 15, 1984.

Table J-31. Acreage of Potential Wetland Types that Would be Crossed by the Healy-to-Willow Transmission Corridor and Percentage of Each Type within the Proposed Transmission Corridor

Wetland Type	Potential Wetland Area Crossed (acres)†[1]			Percentage of Transmission Corridor†[2]
	Gold Creek to Healy	Gold Creek to Willow	Total	
Palustrine forested, needle-leaved evergreen	0	830	830	18.0
Palustrine forested, broad-leaved deciduous	15	330	340	7.4
Palustrine scrub-shrub, broad-leaved deciduous	1,000	790	1,800	39.1
Palustrine or lacustrine emergent, persistent	270	0	270	5.9
Lacustrine	0	0	0	0
Riverine	0	0	0	0
Total Potential Wetland Area	1,300	2,000	3,300	71.7

†[1] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreage of proposed transmission line corridor (see Table J-30).

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-30 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Table J-32. Acreage of Vegetation Types that Would be Crossed by the Healy-to-Fairbanks Transmission Corridor and Comparison of each Type with the Total Acreage of that Type in the Healy-to-Fairbanks Transmission Corridor Study Area

Vegetation Type†[1]	Vegetated Area Crossed (acres)†[2]	Percentage of Transmission Corridor Study Area†[3]
Forest	2,600	1.2
Woodland spruce	120	3.0
Open spruce	1,400	1.8
Closed spruce	40	1.3
Open deciduous	230	0.7
Closed deciduous	93	0.4
Woodland mixed	23	1.2
Open mixed	390	1.3
Closed mixed	17	0.2
Open spruce/open deciduous	13	0.7
Open spruce/wet sedge-grass/ open deciduous	13	0.3
Open spruce/low shrub/wet sedge-grass/open deciduous	240	1.4
Tundra	290	2.6
Wet sedge-grass	250	4.2
Mesic sedge-grass	16	1.6
Sedge-shrub	20	2.0
Shrubland	610	1.5
Low mixed shrub	530	1.4
Low shrub/wet sedge-grass	80	2.0
Disturbed	17	1.7
Unvegetated	52	0.9
River	52	1.0
Total Vegetated Area	3,500	1.3

†[1] The Tanana Flats area crossed by this transmission corridor (Sec. J.1.2.3.3) is an area characterized by extremely complex mosaics of various vegetation types. As a result, various complexes were recognized and mapped.

†[2] Acreages rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[3] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-15.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.86 (Revised), p. 3B-7-7.

Table J-33. Acreage of Potential Wetland Types that Would be Crossed by the Healy-to-Fairbanks Transmission Corridor and Comparison of Each Type with the Total Acreage of that Type in the Healy-to-Fairbanks Transmission Corridor Study Area

Wetland Type	Potential Wetland Area Crossed (acres)†[1]	Percentage of Transmission Corridor Study Area†[2]
Palustrine forested, needle-leaved evergreen	1,500	1.8
Complexes of Palustrine forested, scrub-shrub, and emergent	260	1.1
Palustrine scrub-shrub, broad-leaved deciduous	610	1.5
Palustrine or lacustrine emergent, persistent	250	4.2
Lacustrine	0	0
Riverine	52	0.9
Total Potential Wetland Area	2,700	1.7

†[1] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†[2] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-16.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-32 using correlations of vegetation types to potential wetland classes as given in Table J-5.

J.2.1.4.4 Willow-to-Anchorage Segment

Construction

Approximately 2,000 acres (810 ha) of vegetation would be crossed by the proposed 400-ft (122-m) wide right-of-way for the Willow-to-Anchorage segment (Table J-34). This area represents the worst-case estimate of vegetation that would be impacted. Closed mixed conifer-deciduous forest and wet sedge-grass tundra are the major vegetation types occurring within the right-of-way; each type represents about 28% of the total vegetated area within the right-of-way. Forest and tall shrub types, which together represent about 62% of the right-of-way, would be the vegetation types most impacted by right-of-way clearing methods.

The worst-case estimate of potential wetland types that would be crossed by the Willow-to-Anchorage transmission segment is 1,100 acres (450 ha) (Table J-35). Although this acreage represents about 2.4% of the wetland area within the Willow-to-Anchorage transmission corridor study area, about 4.4% of the potential palustrine scrub-shrub, broad-leaved deciduous type within the study area would be crossed. However, the Applicant has indicated that site-specific adjustments would be made in the transmission line corridor during detailed alignment studies in order to minimize wetland and floodplain crossings (Exhibit E, Vol. 6A, Chap. 3, p. E-3-290).

Additional construction-related impacts are discussed in Section J.2.1.4.1.

Operation

Operational-phase impacts to vegetation are discussed in Section J.2.1.4.1.

J.2.1.5 Threatened and Endangered Species

At present, no plant taxa known to occur in Alaska are officially listed as threatened or endangered by Federal or state authorities. Therefore, no impacts to threatened or endangered plant species would occur as a result of construction and operation of the Watana development, the Devil Canyon development, the proposed access routes, or the proposed power transmission facilities.

Table J-34. Acreage of Vegetation Types that Would be Crossed by the Willow-to-Anchorage Transmission Corridor and Comparison of each Type with the Total Acreage of that Type in the Willow-to-Anchorage Transmission Corridor Study Area

Vegetation Type	Vegetated Area Crossed (acres)†1	Percentage of Transmission Corridor Study Area†2
Forest	1,300	2.0
Woodland spruce	190	3.2
Open spruce	97	1.2
Closed spruce	190	2.4
Closed deciduous	150	1.7
Open mixed	100	2.5
Closed mixed	560	2.0
Tundra	550	2.4
Wet sedge-grass	550	2.4
Shrubland	220	4.4
Low mixed shrub	220	4.4
Disturbed	17	1.7
Total Vegetated Area	2,000	2.2

†1 Acreages rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†2 Percentages calculated by dividing acreages by total acreages for each type as given in Table J-13.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 6B, Chap. 3, June 30, 1983, Table E.3.86 (Revised), p. 3B-7-7.

Table J-35. Acreage of Potential Wetland Types that Would be Crossed by the Willow-to-Anchorage Transmission Corridor and Comparison of each Type with the Total Acreage of that Type in the Willow-to-Anchorage Transmission Corridor Study Area

Wetland Type	Potential Wetland Area Crossed (acres)†1	Percentage of Transmission Corridor Study Area†2
Palustrine forested, needle-leaved evergreen	290	2.1
Palustrine scrub-shrub, broad-leaved deciduous	220	4.4
Palustrine or lacustrine emergent, persistent	550	2.4
Lacustrine	0	0
Riverine	0	0
Total Potential Wetland Area	1,100	2.4

†1 Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

†2 Percentages calculated by dividing acreages by total acreages for each type as given in Table J-16.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-34 using correlations of vegetation types to potential wetland classes as given in Table J-5.

J.2.2 Susitna Development Alternatives

J.2.2.1 Alternative Dam Locations and Designs

The types of impacts to plant communities caused by use of alternative designs for the proposed dam sites and for related facilities would be essentially similar to those impacts for the proposed project as described in Section J.2.1. Relatively minor refinements in the designs of the dams and relatively small changes in the locations or designs of related facilities, such as the spillways, might cause slight changes in the acreage or types of vegetation removed in comparison to the proposed project, but these changes would probably be insignificant by comparison to the vegetation lost through inundation by the impoundment. Indirect vegetation loss or damage and alteration of plant communities that would be caused by alternative dam and facility designs would be essentially the same as that described in Section J.2.1 except that the actual location and, thus, plant community type affected might change slightly.

Construction and operation of the Watana I alternative would lower the impoundment elevation to 2,100 ft (640 m) and reduce the area inundated to 28,300 acres (11,450 ha) (Wakefield, 1983). Of the 28,300 acres (11,450 ha) that would be inundated, about 24,000 acres (9,700 ha) would be expected to be vegetated. Specific vegetation types that would be lost should be similar to those quantified in Table J-18 except that the relative proportions of each type might change slightly. Since less fill materials would be required for Watana I in comparison to the proposed Watana dam, the acreage of vegetation that would be temporarily lost during excavation of borrow sites and would later require rehabilitation would be less than the acreage quantified in Table J-19 for the proposed Watana dam. Indirect vegetation loss or damage and alteration of plant communities that would be caused by Watana I would be similar to that described in Section J.2.1.1; however, because of the smaller size of the Watana I impoundment, the extent of such impacts would be less than they would be for Watana. The downstream effects on riparian communities that would be caused by regulated flows associated with Watana I operation would be similar to those described in Section J.2.1.1.2, but might affect a slightly lesser area if the regulated flows associated with Watana I are more similar to existing flows than those associated with Watana.

Construction and operation of the Reregulating dam alternative (Fig. 2-17) would result in impacts similar to, but probably less extensive than, impacts to vegetation described in Section J.2.1.2 for the proposed Devil Canyon dam and impoundment. The major difference between this alternative and Devil Canyon is that it would inundate less area [about 4,000 acres (1,600 ha)] and less vegetation [about 3,000 acres (1,200 ha)] than Devil Canyon (see Table J-22). Specific vegetation types that would be lost should be similar to those quantified in Table J-22, although the relative proportions of each type might change slightly. Additionally, the extent of indirect vegetation loss or damage and alteration of plant communities caused by the Reregulating dam alternative would likely be less than they would be for Devil Canyon.

Construction and operation of the Modified High Devil Canyon alternative (Fig. 2-17) would also result in impacts similar to, but probably less extensive than, those of the proposed Devil Canyon dam and impoundment (see Sec. J.2.1.2). Although vegetation (primarily mixed conifer-deciduous forest) located in the 5 mi (8 km) between the Modified High Devil Canyon alternative dam site and the Devil Canyon dam site would not be inundated by the Modified High Devil Canyon alternative, the higher reservoir elevation of this alternative would cause inundation of vegetation higher up the canyon slopes than would occur with the proposed Devil Canyon impoundment. As a rough estimate, the Modified High Devil Canyon alternative would inundate about 6,800 acres (2,750 ha), of which approximately 5,100 acres (2,100 ha) would be vegetated. Specific vegetation types that would be lost should be similar to those quantified in Table J-22, although the relative proportions of each type might change slightly. Also, the extent of indirect vegetation loss or damage and alteration of plant communities associated with this alternative would probably be slightly less than for Devil Canyon.

J.2.2.2 Alternative Access Routes

Construction of the northern or southern access alternatives (see Sec. 2.2.2.4 and Fig. 2-13) would result in clearing and permanent loss of about 810 acres (330 ha) or 980 acres (400 ha) of vegetation, respectively (Table J-36). These areas each amount to about 0.02% of the vegetation within the upper and middle Susitna Basin. For the northern access alternative about 40% of the vegetation removed would be forest types, principally woodland and open white spruce forest; whereas, tall shrub and low shrub types would account for 20% and 33% of the vegetation removed, respectively. Almost 60% of the vegetation that would be removed for the southern access alternative would be forest types. Mixed conifer-deciduous and open spruce forests would be the major forest types lost. Tall and low shrub types occurring in roughly equal proportions cover about a third of the southern access alternative.

About 510 acres (210 ha) of potential wetland types might be cleared for the northern access alternative; whereas, only 420 acres (170 ha) of potential wetland types would be cleared for the southern access alternative (Table J-37). As explained in Section J.2.1.1, the areas in

Table J-36. Acreages of Vegetation Types that Would Be Cleared for the Northern and Southern Alternative Access Corridors and Comparison of Each Vegetation Type with the Total Acreage for that Type in the Upper and Middle Susitna Basin

	Vegetated Area Cleared (acres) and Percentage of Basin Total for Respective Type†[1,2]			
	Northern Alternative		Southern Alternative	
Vegetation Type	acres	%	acres	%
Forest	320	0.04	570	0.07
Woodland black spruce			10	0.02
Woodland white spruce	100	0.02	61	
Open black spruce	4	0.05	60	0.06
Open white spruce	130		110	
Open birch	3	0.2	4	0.2
Closed balsam poplar			1	†[3]
Open mixed	28	0.05	71	0.1
Closed mixed	58	0.1	250	0.6
Tundra	60	0.01	91	0.01
Wet sedge-grass	6	0.05	6	0.05
Mesic sedge-grass			3	<0.01
Sedge-shrub	25	†[3]	38	†[3]
Mat and cushion	26	0.02	45	0.03
Grassland	2	†[3]		
Shrubland	430	0.03	320	0.02
Open tall shrub	44	0.05	60	0.05
Closed tall shrub	120		86	
Birch shrub	160	0.2	70	0.08
Willow shrub	25	0.1	16	0.06
Mixed low shrub	86	0.01	87	0.01
Total Vegetated Area	810	0.02	980	0.03

†[1] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-7.

†[2] Acreages rounded to two significant figures; values do not add up to totals for each major vegetation type due to rounding errors.

†[3] These vegetation types were not quantified in Table J-7.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Based on Supplemental Information to Exhibit E, Vol. 9, Chap. 10, June 30, 1983, pp. 10-14-1 - 10-14-2.

Table J-37. Acreages of Potential Wetland Types that Would Be Cleared for the Northern and Southern Alternative Access Corridors and Comparison of Each Wetland Type with the Total Acreage for that Type in the Upper and Middle Susitna Basin

	Potential Wetland Area Cleared (acres) and Percentage of Basin Total for Respective Type†[1,2]			
	Northern Alternative		Southern Alternative	
Wetland Type	acres	%	acres	%
Palustrine forested, needle-leaved evergreen	230	0.03	240	0.03
Palustrine forested, broad-leaved deciduous	0	0	1	0.1
Palustrine scrub-shrub, broad-leaved deciduous	270	0.02	170	0.01
Palustrine or lacustrine emergent, persistent	6	0.05	6	0.05
Lacustrine	0	0	0	0
Riverine	0	0	0	0
Total Potential Wetland Area	510	0.02	420	0.02

†[1] Percentages calculated by dividing acreages by total acreages for each type as given in Table J-12.

†[2] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Values do not add up to totals due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-36 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Table J-37 are extremely liberal estimates based on correlation to the Viereck and Dyrness (1980) vegetation classification system (see Table J-5).

Temporary loss of vegetation might occur as a result of construction-related activity outside the actual alternative access route alignments. Although the Applicant has proposed construction methods to reduce requirements for fill material (Exhibit E, Vol. 6A, Chap. 3, p. E-3-264 - E-3-266), some borrow areas might be required. If borrow areas are required, clearing as well as storage of overburden and soil could also result in temporary loss of vegetation. On the basis of contingency borrow sites identified for the proposed access route, it can be estimated that, as a worst-case situation, about 300 acres (120 ha) of vegetation might be temporarily removed during borrow excavation for either alternative access route. Rehabilitation of these types of disturbance has been described in Sections J.2.1.1.1 and J.2.1.3.1.

Potential indirect construction effects to vegetation as well as potential operational impacts to vegetation have been discussed in Section J.2.1.3.1.

J.2.2.3 Alternative Power Transmission Routes

The acreages of various vegetation types that would be crossed by technically and economically feasible alternative power transmission routes (Exhibit E, Vol. 9, Chap. 10, Table E.10.24) were estimated by the Applicant (Supplemental Information to Exhibit E, Vol. 9, Chap. 10, June 30, 1983, pp. 10-20-1 - 10-20-4). In the northern study area (Fig. 2-15), the right-of-way for alternative power transmission route ABDC would cross about 3,100 acres (1,250 ha) of vegetation (Table J-38). In the central study area (Fig. 2-14), the rights-of-way for the six transmission

Table J-38. Acreages of Vegetation Types that Would Be Crossed by Alternative and Proposed Transmission Corridors in the Northern and Southern Study Areas†[1,2]

	Vegetated Area Crossed (acres) by each Corridor†[3]				
	Northern Study Area		Southern Study Area		
Vegetation Type	ABDC	Proposed	ABC'	AEFC	Proposed
Forest	2,200	2,500	2,800	930	900
Conifer	1,500	1,500	72	350	270
Deciduous	340	380	850	100	96
Mixed	390	630	1,900	470	540
Tundra	0	0	280	700	270
Mesic sedge-grass					79
Wet sedge-grass			280	700	190
Shrubland	930	730	200	40	230
Tall shrub	270	120	160		
Low shrub	660	610	43	40	230
Sphagnum bog	0	0	20	260	580
Unvegetated	59	59	330	0	0
Water	44	22	53		
Disturbed	15	37	270		
Total Vegetated Area	3,100	3,200	3,300	1,900	2,000

†[1] Only technically and economically feasible alternatives were considered (see Exhibit E, Vol. 9, Chap. 10, Table E.10.24).

†[2] Acreages of vegetation types crossed by proposed corridors are included in this table because acreages presented in this table were derived by the Applicant from 1:250,000-scale State of Alaska, Department of Natural Resources vegetation maps for the Fairbanks, Healy, and Anchorage Quads and are not directly comparable to the acreages presented for the proposed corridors in Tables J-32 and J-34.

†[3] Acreages rounded to two significant figures; corridor width equals 300 ft (91 m) for the northern study area and 400 ft (122 m) for the southern study area. Values do not add up to totals for each major vegetation type due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 9, Chap. 10, June 30, 1983, pp. 10-20-1 - 10-20-4.

route alternatives would cross varying acreages of vegetation, ranging from 1,300 acres (530 ha) for corridor AJCF to 3,000 acres (1,200 ha) for corridor CJAHI (Table J-39). In the southern study area (Fig. 2-16), 3,300 acres (1,300 ha) of vegetation would be crossed by the right-of-way for alternative ABC'; whereas 1,900 acres (770 ha) of vegetation would be crossed by alternative AEFC (Table J-38). These areas represent a worst-case estimate of vegetation to be impacted, since only the forest and tall shrub types (because of their overstory layer heights) would require major clearing. In most cases, forest and tall shrub communities cover larger acreages in the alternative rights-of-way than in the corresponding proposed rights-of-way (see Tables J-38 and J-39, note first footnote in each table). The only exceptions to this are alternative ABDC in the northern study area and alternative AJCF in the central study area.

The Applicant has indicated that site-specific adjustments would be made in the transmission line corridors during detailed alignment studies in order to minimize wetland and floodplain crossings (Exhibit E, Vol. 6A, Chap. 3, p. E-3-290). However, worst-case estimates of potential wetland types (based on correlation to vegetation types; see Section J.2.1.1.1) that would be crossed by the alternative transmission line rights-of-way are presented in Tables J-40 and J-41.

Additional possible alternative transmission line corridors in the northern and southern study areas (as identified in Wakefield, 1983) would cross similar types of vegetation as the alternatives identified in Table J-38 although the specific proportions of various vegetation types contributing to the total acreage would be different. For example, some of these alternatives are located closer to rivers or creeks and, thus, might cross more floodplain communities. If these alternatives parallel existing rights-of-way for roads, rail lines, or other transmission lines, then impacts to vegetation caused by clearing for access might be less than for other alternatives. However, without more detailed vegetation studies and more specific information on access locations to the corridors, it is impossible to identify the alternatives with the least impacts on the basis of botanical resources.

Other potential impacts to vegetation from construction and operation of the alternative power transmission routes would be similar to those already discussed in Section J.2.1.4.1.

J.2.2.4 Alternative Borrow Sites

With the exception of borrow site J, which is contained within the Susitna River (Fig. 2-2), use of the alternative borrow sites would result in the temporary removal of vegetation from these sites. Vegetation and soils would be cleared prior to excavation, and the areas would be rehabilitated as outlined in Section J.2.1.1.1. The acreages of vegetation cleared for borrow sites B and L (Fig. 2-2) would be relatively small; whereas, about 1,500 acres (610 ha) of vegetation would be cleared for borrow Site C (Fig. 2-6) (Exhibit E, Vol. 9, Chap. 10, pp. E-10-87, E-10-88, and E-10-99).

J.2.2.5 Threatened and Endangered Species

At present, no plant taxa known to occur in Alaska are officially listed as threatened or endangered by Federal or state authorities. Therefore, no impacts to threatened or endangered species would occur as a result of the Susitna development alternatives.

J.2.3 Non-Susitna Generation Alternatives

J.2.3.1 Natural-Gas-Fired Generation Scenario

Construction of facilities associated with each of the 200-MW combined-cycle units and each of the 70-MW combustion-turbine units in the natural-gas-fired generation scenario would result in the permanent removal of 5 acres (2 ha) of vegetation. Thus, a total of about 50 acres (20 ha) of vegetation would be permanently lost as a result of the implementation of this scenario (see Table J-42). Since the gas-fired units do not produce solid wastes, no vegetation would have to be cleared for a solid-waste disposal area. Placement of gas pipeline spurs to the plants would probably require temporary removal or disturbance and subsequent rehabilitation of relatively narrow and short corridors of vegetation. In addition, relatively short [less than 10 mi (16 km)] transmission line stubs would probably be constructed to the plants resulting in vegetation impacts similar to those described in Section J.2.1.4. If in addition to transmission line stubs to the plants it is assumed that transmission of the power to the Railbelt would require, at least, (1) construction of two 345-kV lines from Willow to Anchorage and from Healy to Fairbanks and (2) upgrading of the existing intertie between Healy and Willow to two 345-kV lines, then at least 9,000 acres (3,640 ha) of vegetation might be disturbed by construction and operation of power transmission facilities. Gaseous combustion emissions of SO_2 and NO_x are expected to be low enough that no impacts to even sensitive plant species from these pollutants would be likely (Dvorak et al., 1978). Impacts to wetlands would probably be minimal if it is assumed that facilities would be sited to avoid critical or sensitive wetland areas.

Table J-39. Acreages of Vegetation Types that Would Be Crossed by Alternative and Proposed Transmission Corridors in the Central Study Area and Comparison of Each Vegetation Type with the Total Acreage for that Type in the Upper and Middle Susitna Basin†[1,2]

	Vegetated Area Crossed (acres) by each Corridor and Percentage of Basin Total for Respective Type†[3]													
	ABCD		ABCF		ABECD		ABECF		AJCF		CJAHI		Proposed	
Vegetation Type	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
Forest	1,400	0.2	980	0.1	1,500	0.2	1,100	0.1	580	0.07	430	0.05	970	0.1
Woodland spruce	230	0.05	230	0.05	280	0.06	280	0.06			120	0.03		
Open spruce	220	0.07	220	0.07	240	0.08	240	0.08	15	0.01	15	0.01	15	0.01
Open mixed	94	0.2	300	0.5	140	0.2	350	0.6	390	0.7	210	0.4	180	0.3
Closed mixed	830	2.1	230	0.6	820	2.1	220	0.6	170	0.4	86	0.2	770	2.0
Tundra	0	0	0	0	96	0.01	96	0.01	120	0.01	740	0.08	120	0.01
Mesic sedge-grass					7	<0.01	7	<0.01						
Mat and cushion					25	0.02	25	0.02			400	0.2		
Mat and cushion/ sedge-grass					64	0.02	64	0.02	120	0.03	120	0.03	120	0.03
Alpine herbaceous											220	11.0		
Shrubland	310	0.02	550	0.03	320	0.02	560	0.04	640	0.04	1,800	0.1	410	0.03
Open tall shrub	22	0.01	260	0.08	37	0.01	270	0.08	360	0.1	750	0.2	120	0.04
Birch shrub	290	0.3	290	0.3	260	0.3	260	0.3	100	0.1	320	0.4	100	0.1
Willow shrub					15	0.06	15	0.06	180	0.7	180	0.7	180	0.7
Mixed low shrub					17	<0.01	17	<0.01			510	0.04		
Unvegetated	25	<0.01	0	0	40	0.01	15	<0.01	15	<0.01	510	0.08	40	0.01
Water	25	0.03			40	0.04	15	0.02	15	0.02	15	0.02	40	0.04
Rock											99	0.04		
Snow and ice											400	0.2		
Total Vegetated Area	1,700	0.05	1,500	0.04	1,900	0.06	1,700	0.05	1,300	0.04	3,000	0.09	1,500	0.04

†[1] Only technically and economically feasible alternatives were considered (see Exhibit E, Vol. 9, Chap. 10, Table E.10.24).

†[2] Acreages of vegetation types crossed by the proposed corridor are included in this table because acreages presented in this table were derived by the Applicant from Figure E.3.38 primarily (Exhibit E, Vol. 6B, Chap. 3) and are not directly comparable to the acreages presented for the proposed corridor in Table J-28.

†[3] Acreages rounded to two significant figures; corridor width equals 300 ft (91 m) in areas with two circuits and 510 ft (155 m) in areas with four circuits. Values do not add up to totals for each major vegetation type due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Supplemental Information to Exhibit E, Vol. 9, Chap. 10, June 30, 1983, pp. 10-20-1 and 10-20-3.

Table J-40. Acreages of Potential Wetland Types that Would Be Crossed by Alternative and Proposed Transmission Corridors in the Northern and Southern Study Areas†[1,2]

	Potential Wetland Area Crossed (acres) by each Corridor†[3]				
	Northern Study Area		Southern Study Area		
Wetland Type	ABDC	Proposed	ABC'	AEFC	Proposed
Palustrine forested, needle-leaved evergreen	1,500	1,300	72	350	270
Palustrine forested, broad-leaved deciduous	140	180	0	0	0
Palustrine scrub-shrub, broad-leaved deciduous	660	610	43	40	230
Palustrine or lacustrine emergent, persistent	0	0	300	960	770
Lacustrine/Riverine	0	0	53	0	0
Riverine	44	22	0	0	0
Total Potential Wetland Area	2,300	2,200	470	1,300	1,300

†[1] Only technically and economically feasible alternatives were considered (see Exhibit E, Vol. 9, Chap. 10, Table E.10.24).

†[2] Acreages of potential wetland types crossed by proposed corridors are included in this table because acreages in this table were derived by the Applicant by correlating vegetation types from 1:250,000-scale State of Alaska, Department of Natural Resources vegetation maps for the Fairbanks, Healy, and Anchorage Quads to wetland types of Cowardin et al. (1979) and are not directly comparable to the acreages presented for the proposed corridors in Tables J-33 and J-35.

†[3] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Corridor width equals 300 ft (91 m) for the northern study area and 400 ft (122 m) for the southern study area. Values do not add up to totals due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-38 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Table J-41. Acreages of Potential Wetland Types that Would Be Crossed by Alternative and Proposed Transmission Corridors in the Central Study Area and Comparison of Each Wetland Type with the Total Acreage for that Type in the Upper and Middle Susitna Basin†[1,2]

	Potential Wetland Area Crossed (acres) by each Corridor and Percentage of Basin Total for Respective Type†[3]													
	ABCD		ABCF		ABECD		ABECF		AJCF		CJAHI		Proposed	
Wetland Type	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
Palustrine forested, needle-leaved evergreen	450	0.06	450	0.06	520	0.07	520	0.07	15	<0.01	140	0.02	15	<0.01
Palustrine scrub-shrub, broad-leaved deciduous	290	0.02	290	0.02	290	0.02	290	0.02	280	0.02	1,000	0.08	280	0.02
Palustrine or lacustrine emergent, persistent	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riverine/Lacustrine	25	0.03	0	0	40	0.04	15	0.02	15	0.02	15	0.02	40	0.04
Total Potential Wetland Area	770	0.04	740	0.03	840	0.04	820	0.04	310	0.01	1,200	0.06	340	0.02

†[1] Only technically and economically feasible alternatives were considered (see Exhibit E, Vol. 9, Chap. 10, Table E.10.24).

†[2] Acreages of potential wetland types crossed by the proposed corridor are included in this table because acreages in this table were derived by the Applicant by correlating vegetation types from Figure E.3.38 (Exhibit E, Vol. 6B, Chap. 3) to wetland types of Cowardin et al. (1979) and are not directly comparable to the acreages presented for the proposed corridor in Table J-29.

†[2] Acreages based on correlation of vegetation types to wetland types of Cowardin et al. (1979) as in Table J-5, and rounded to two significant figures. Corridor width equals 300 ft (91 m) in areas with two circuits and 510 ft (155 m) in areas with four circuits. Values do not add up to totals due to rounding errors.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Calculated from data in Table J-39 using correlations of vegetation types to potential wetland classes as given in Table J-5.

Table J-42. Potential Acreages of Vegetation Permanently Removed for Construction of Facilities Associated with Natural-Gas-Fired Units at Each Location for the Natural-Gas-Fired Generation Scenario

Location	Plant Type†1	Number of Units	Potential Acreage of Vegetation Removed
Lower Beluga River	Combined-cycle	2	10
Chuitna River	Combined-cycle	3	15
Kenai	Combined-cycle	2	10
Southeast of Anchorage	Combined-cycle	1	5
Anchorage	Combustion-turbine	2	10
TOTAL			50

†1 Combined-cycle units would be 200 MW each, combustion-turbine units would be 70 MW each.

Conversion: To convert acres to hectares, multiply by 0.405.

J.2.3.2 Coal-Fired Generation Scenario

Construction of facilities associated with the five 200-MW coal units and the ten 70-MW gas combustion-turbine units of the coal-fired generation scenario could result in the permanent removal or disturbance of about 600 acres (240 ha) of vegetation (Table J-43). Over the 30-year life of the coal units an additional total of about 225 acres (90 ha) of vegetation would be temporarily removed for solid waste disposal at the plant sites, and a total of about 2,250 acres (910 ha) of vegetation would be temporarily removed during surface coal mining. It would be expected that the waste disposal and surface mine sites would eventually be rehabilitated. If soils could be adequately restored on these areas, rehabilitation should be no more difficult than the rehabilitation of borrow sites or other temporary facilities planned for the proposed Susitna project (see Sec. J.2.1.1.1). Temporary removal or disturbance of vegetation that would be associated with construction of transmission line stubs or gas pipeline spurs has been described in Section J.2.3.1. As with the natural-gas-fired generation scenario, transmission of power to the Railbelt would require construction and operation of power transmission facilities that could disturb about 9,000 acres (3,640 ha) of vegetation (see Sec. J.2.3.1).

Localized alteration or damage of plant communities might result from fugitive dusting near coal mine pits, along transportation routes, near coal storage piles at the plant, the mine, and transportation loading facilities, and near waste disposal sites (see Sec. J.2.1.1.1). Specific effects would be dependent upon site-specific parameters such as wind conditions, plant community type, chemical composition of the dust, and the magnitude of dust-control efforts. Trace elements in runoff or seepage from solid-waste disposal areas might have some localized effects on vegetation surrounding the site. However, the chances of adverse effects would probably be low since the waste would be dry rather than a slurry (Dvorak et al., 1978). In addition, liners could be employed if site-specific evaluations indicated they would be necessary to reduce seepage to groundwater and adjacent soils.

Considering the high particulate removal efficiency (99.95%) assumed for the coal units, no impacts to vegetation from particulates or trace element combustion emissions would be expected. On the basis of screening modeling for dispersion of combustion emissions (see App. G, Sec. G.2.4), SO_2-sensitive plant species would probably not suffer acute injury or damage, except perhaps at specific locations under worst-case fumigation conditions. Even for three 200-MW units at Nenana, the maximum annual 3-hr average SO_2 concentrations at ground level (at elevated terrain locations) under worst-case fumigation conditions would be less than 275 $\mu g/m^3$ (assuming maximum annual 3-hr averages are roughly 2.5 times the maximum annual 24-hr averages; see App. G, Table G-10). This dosage level is right at the lowest level of the threshold range for acute injury of sensitive species (Dvorak et al., 1978). This means that although damage to sensitive species is not likely, there is a very slight possibility that injury or damage could occur in some sensitive species at certain locations under worst-case conditions. Species with intermediate SO_2-sensitivity or SO_2-resistant species would not be injured even under worst-case conditions. Many nonvascular plants as well as trembling aspen, paper birch, and some alder species are considered SO_2-sensitive species; balsam poplar and western hemlock are considered

Table J-43. Potential Acreages of Vegetation Permanently and Temporarily Removed for Construction of Facilities, Waste Disposal, and Surface Mining Associated with the Coal- and Natural-Gas-Fired Units at each Location in the Coal-Fired Generation Scenario

			Potential Acreage of Vegetation Removed		
			Permanent	Temporary	
Location	Plant Type†[1]	Number of Units	Plant Facilities	Solid Waste Disposal†[2]	Surface Mining†[2]
Willow	Coal unit	2	250	90	900
Nenana	Coal unit	3	300	135	1,350
Tyonek-Beluga area	Gas combustion-turbine	6-7	30-35	0	0
Anchorage	Gas combustion-turbine	2	10	0	0
Kenai	Gas combustion-turbine	1-2	5-10	0	0
TOTAL			600	225	2,250

†[1] Coal units would be 200 MW each, combustion-turbine units would be 70 MW each.

†[2] Assumes 30-year operating life of each unit.

Conversion: To convert acres to hectares, multiply by 0.405.

to have intermediate SO_2-sensitivity; and white spruce, black spruce, and willow species are considered by some sources to have intermediate sensitivity and by others to be relatively SO_2-resistant (Dvorak et al., 1978; Malhotra and Blauel, 1980). Although the potential for SO_2-induced chronic or long-term injury or alteration of plant communities near the coal units exists, it is impossible to predict whether or not such effects would actually occur because little information on chronic or long-term injury threshold levels exists in the literature. It is unlikely that vegetation in the vicinity of the coal units would be directly affected by NO_x emissions. For three 200-MW units, the maximum annual 3-hr average NO_x concentrations at ground level under worst-case fumigation conditions would be about 225 $\mu g/m^3$, which is well below the acute and chronic threshold injury levels (about 2,000 $\mu g/m^3$) for plants (Dvorak et al., 1978). However, NO_x emissions could contribute to the formation of secondary pollutants such as ozone or peroxyacetyl nitrate (PAN) through reactions with airborne hydrocarbons, and NO_x together with SO_2 and ozone might cause greater injury than any one of the pollutants would alone (Dvorak et al., 1978). Impacts to wetlands would probably be minimal if it is assumed that facilities would be sited to avoid critical or sensitive wetland areas.

J.2.3.3 Combined Hydro-Thermal Generation Scenario

Construction of the various dams, impoundments, diversions, lake traps, and associated facilities at the Johnson, Keetna, Snow, Browne, and Lake Chakachamna sites, and the various thermal facilities of the combined hydro-thermal generation scenario would result in the permanent or temporary removal of about 103,000 acres (41,700 ha) of vegetation either with or without Lake Chakachamna (Table J-44). Indirect vegetation loss or damage and alteration of plant communities as a result of construction and operation of these hydropower sites, as well as associated access roads and transmission lines, would likely occur and would be similar in type to those impacts described in Section J.2.1. As with the natural-gas- and coal-fired generation scenarios, transmission of power to the Railbelt would require construction and operation of power transmission facilities that could disturb about 9,000 acres (3,640 ha) of vegetation (see Sec. J.2.3.1). In addition, construction and operation of transmission line stubs to each of the dam sites and thermal units (as described in Secs. 2.3.3 and 2.5.3) could potentially disturb another 4,800 acres (1,940 ha) of vegetation with Lake Chakachamna or another 3,500 acres (1,420 ha) without Lake Chakachamna. Thus, a total of about 12,500 to 13,800 acres (5,060 to 5,580 ha) of vegetation could be disturbed by transmission facilities for this scenario. Impacts to wetlands caused by development of the hydropower sites would be similar to those described in Section J.2.1, but might vary depending on site-specific conditions. It is impossible to predict such impacts at this time. Non-transmission related impacts to vegetation from the thermal facilities of this scenario have been described in Sections J.2.3.1 and J.2.3.2.

Table J-44. Potential Acreages of Vegetation Permanently or Temporarily Removed by Inundation, Construction of Facilities, Waste Disposal, and Surface Mining Associated with the Combined Hydro-Thermal Generation Scenario, both with and without Lake Chakachamna

			Potential Acreage of Vegetation Permanently or Temporarily Removed	
Location	Type†[1]	Number of Units	With Chakachamna	Without Chakachamna
Johnson	Hydro (dam and impoundment)	-	84,000†[2]	84,000†[2]
Keetna	Hydro (dam and impoundment)	-	4,800†[2]	4,800†[2]
Snow	Hydro (dam and impoundment)	-	2,600†[2]	2,600†[2]
Browne	Hydro (dam and impoundment)	-	10,640†[2]	10,640†[2]
Lake Chakachamna	Hydro (lake tap)	-	Negligible†[2]	0
Nenana	Coal	1	695†[3]	695†[3]
Chuitna River	Combined-cycle	2	10	10
Anchorage	Combustion-turbine	3	15	15
Lower Beluga River	Combined-cycle	1 or 2†[4]	5	10
TOTAL			102,765	102,770

†[1] Coal and combined-cycle units would be 200 MW each, combustion-turbine units would be 70 MW each; hydro units would vary.

†[2] Acreages are estimates of area to be inundated including unvegetated areas such as rivers. On the other hand, acreages of vegetation removed for construction of associated facilities and access roads have not been included in these estimates.

†[3] Includes 200 acres for plant facilities, 45 acres for solid waste disposal, and 450 acres for surface mining over the 30-year operating life of the unit.

†[4] One unit with Chakachamna and two units without Chakachamna.

Conversion: To convert acres to hectares, multiply by 0.405.

J.2.3.4 Threatened and Endangered Species

At present, no plant taxa known to occur in Alaska are officially listed as threatened or endangered by Federal or state authorities. Therefore, no impacts to threatened or endangered species would occur as a result of the non-Susitna power generation alternatives.

J.2.4 Comparison of Alternatives

J.2.4.1 Susitna Development Alternatives

Comparison of the alternative dam locations and designs has been incorporated into the compari son of power generation scenarios (Section J.2.4.2). A comparison of the access alternatives (Tables J-26 and J-36) indicates that the proposed route would be the longest and would, therefore, disturb more vegetation. The proposed route would disturb more tundra and shrub types and less forest types than the two alternatives. In addition the proposed route would disturb more potential wetland area than the two alternatives (1.5 and 1.8 times for the northern and southern alternatives, respectively; see Tables J-27 and J-37). The Applicant has indicated, however, that wetlands between Hurricane and Indian River in both the northern and southern alternative routes would have a relatively high potential for causing drainage alterations, because soils in these areas have a poor bearing capacity, and might cause excessive settlement of the road in some areas, making installation and maintenance of culverts difficult (Supplemental Information to Exhibit E, Vol. 9, Chap. 10, June 30, 1983, pp. 10-15-1 - 10-15-2). The Applicant also indicated that the proposed Denali Highway-to-Watana route does not have any wetland areas with as high a potential for drainage alterations. However, the proposed route could provide increased access to greater land areas than either of the alternatives, thereby increasing the potential for increased human-use impacts to vegetation (e.g., increased fire incidence and ORV/ATV usage) unless measures were taken to limit or prevent use of the access roads after construction of the project was completed.

A comparison of the alternative power transmission routes indicates that the proposed routes would cross neither the most nor the least vegetation (Tables J-38 and J-39, note first footnotes in each table). Forest and tall shrub types, because of their overstory layer heights and greater clearing requirements, would be most disturbed by the transmission lines. In most cases, the proposed corridors would cross less forest and tall shrub communities than would the alternatives. The only exceptions to this are alternative ABDC in the northern study area and alternative AJCF in the central study area. However, the areas of forest and tall shrub that would be crossed by each of these alternatives is not that much less [about 150 acres (61 ha)] than the areas of these types that would be crossed by the proposed corridors. The potential wetland areas crossed by the proposed corridors (Tables J-40 and J-41) would be less than those crossed by the alternatives except for alternative ABC' in the southern study area and alternative AJCF in the central study area. Unless more specific information about tower placement, access locations, and the locations of valuable vegetation or wetland types is known, it is difficult to provide a definitive comparison of corridors on the basis of botanical resources alone.

The alternative borrow sites are compared by size and vegetation occurrence in Tables J-19, J-21, J-23, and J-25 and Sections J.1.3.4 and J.2.2.4. Relative to impacts to vegetation, alternative borrow sites that would be inundated by the impoundments would have the least additional effect on vegetation; whereas, those sited along the banks of otherwise undisturbed creeks might present more difficulties in rehabilitation. Depending upon the depth of the sites and provisions made for regrading steep slopes, quarry sites (A, B, K, and L) might be more difficult to rehabilitate than borrow sites (C, D, E, F, G, H, I, and J).

J.2.4.2 Power Generation Scenarios

A comparison of the impacts to vegetation for the various alternative power generation scenarios (including Susitna as proposed and the alternative Susitna developments) is presented in Table J-45. This comparison indicates that the alternative Susitna developments would remove or disturb less vegetated area (about 82% to 88%) than would the proposed project. However, the natural-gas-fired and coal-fired generation scenarios would have the least effects on vegetation. Vegetation removed or disturbed by the natural-gas-fired and coal-fired scenarios would be about 16% and 22%, respectively, of the vegetated area affected by the proposed project. Furthermore, each of these thermal scenarios would have fewer indirect effects on vegetation than would any of the alternative scenarios with hydropower sites. Due to the very large impoundment area estimated for the Johnson site [84,000 acres (34,000 ha)], the combined hydrothermal scenario would probably disturb more than twice as much vegetated area [over 115,000 acres (46,500 ha)] as the proposed Susitna project.

J.2.5 Conclusions

J.2.5.1 Proposed Project

- Construction of the proposed Watana and Devil Canyon dams and impoundments, related facilities, and access roads would result in the direct removal of about 44,000 acres (17,800 ha) of vegetation, or about 1.3% of the vegetated area within the upper and middle Susitna Basin. More specifically, about 4% of all forested areas, about 10% of mixed conifer-deciduous forest types, about one-third of the paper birch forest stands, and less than 1% of the tundra and shrubland types within the upper and middle Susitna Basin would be removed.

- More than 80% [37,000 acres (15,000 ha)] of the vegetation that would be removed could also be considered potential wetland areas. This represents about 1.7% of the potential wetland areas within the upper and middle Susitna Basin.

- Following completion of the proposed Watana and Devil Canyon dams and impoundments, about 6,400 acres (2,600 ha), or about 15% of the total vegetated area removed during construction, would require rehabilitation to prevent future erosion, vegetation and wildlife habitat loss, and visual and recreational impacts.

- In addition to the areas described above, about 12,000 acres (4,900 ha) of vegetation (of which almost two-thirds might also be considered potential wetlands) would be crossed by the proposed power transmission corridors and would be subject to selective clearing. Forest and tall shrub types, which represent almost 60% of the vegetation crossed by the corridors, would be most impacted by clearing because of the height of overstory vegetation.

- The regulated flows and changes in ice processes associated with Watana and Devil Canyon operation would variously affect the development of riparian plant communities downstream of the dam sites, but specific effects are difficult or impossible to reliably predict or quantify.

Table J-45. Comparison of Estimated Quantifiable and Unquantifiable Disturbance to Vegetation Among the Power Generation Scenarios

Scenario	Permanent or Long-Term Vegetation Removal (acres)		Temporary Vegetation Removal (acres)†[1]	Vegetated Area Disturbed by Transmission Facilities (acres)†[2]	Total Quantifiable Vegetated Area Disturbed (acres)	Potential Unquantifiable Indirect Effects to Vegetation†[3]
	Dams, Impoundments, Construction of Permanent Facilities	Access	Temporary Facilities, Borrow Areas, Waste Disposal, Mining			
Proposed Susitna Project						
Watana-Devil Canyon	36,900	1,100	6,400	11,700	56,100	A,B,C,D,E,F,G,H
Alternative Susitna Developments						
Watana I-Devil Canyon	29,900	1,100	6,400	11,700	49,100	A,B,C,D,E,F,G,H
Watana I-Reregulating Dam	27,000	1,100	6,400	11,700	46,200	A,B,C,D,E,F,G,H
Watana I-Modified High Devil Canyon	29,100	1,100	6,400	11,700	48,300	A,B,C,D,E,F,G,H
Natural-Gas-Fired	50	N.D.†[4]	N.A.†[5]	9,000+	9,050+†[6]	A,B,C,F
Coal-Fired	600	N.D.	2,475	9,000+	12,075+	A,B,C,F,G,H
Combined Hydro-Thermal						
Johnson, Keetna, Snow, Browne, Chakachamna	102,040	N.D.	N.D.	13,600	115,640+	
Thermal Units	230	N.D.	495	200+	925+	
Total	102,270	N.D.	495+	13,800+	116,565+	A,B,C,D,E,F,G,H
Johnson, Keetna, Snow, Browne	102,040	N.D.	N.D.	12,300	114,340+	
Thermal Units	235	N.D.	495	200+	930+	
Total	102,275	N.D.	495+	12,500+	115,270+	A,B,C,D,E,F,G,H

†[1] The use of the word temporary implies that the area would eventually be rehabilitated.

†[2] For natural-gas-fired, coal-fired, and combined hydro-thermal scenarios, assumes (1) construction of two 345 kV lines from Willow to Anchorage and from Healy to Fairbanks and (2) upgrading of existing intertie between Healy and Willow to two 345 kV lines as well as construction of lines described in Sections 2.3.3 and 2.5.3 to the various dam sites and thermal units.

†[3] Caused by: A = erosion, slumpage, or permafrost thaw; B = alteration of drainage patterns; C = fugitive dusting; D = climatic changes; E = downstream flow changes; F = increased human use or access; G = potential for seepage from waste disposal areas, H = slight potential for air pollutant effects.

†[4] N.D. = Not determined.

†[5] N.A. = Not applicable.

†[6] "+" indicates an additional undeterminable acreage; these amounts would likely be higher for hydropower sites than for thermal sites due to greater constraints on siting.

Conversion: To convert acres to hectares, multiply by 0.405.

- An additional unquantifiable acreage of vegetation would be indirectly lost, damaged, and/or altered due to factors such as erosion, permafrost thaw, slumpage, wind, fugitive dust, alteration of drainage patterns, mesoclimatic changes, and increased human activities and usage caused by construction and operation of the proposed Susitna project.

J.2.5.2 Alternatives

- Impacts to vegetation from alternative Susitna dam locations and designs, access routes, power transmission routes, and borrow sites would be similar in type and magnitude to impacts of the proposed project.

- The combined hydro-thermal generation scenario would result in the direct removal or disturbance of more than 115,000 acres (46,500 ha) of vegetation (or more than twice the vegetated area that would be affected by the proposed project), as well as other types of impacts similar to those identified for the proposed project.

J.3 MITIGATION

J.3.1 Measures Proposed by the Applicant

The Applicant's proposed plan for mitigation of impacts to botanical resources includes implementation of the following measures (listed in order of priority):

- Avoidance of impact through project design and operation, or by not taking a certain action;

- Minimization of impact by reducing the degree or magnitude of the action, or by changing its location;

- Rectification of impact by repairing, rehabilitating, or restoring the affected portion of the environment;

- Reduction of impact over time by identification of areas where rectification measures can begin or require maintenance efforts over the life of the action;

- Compensation for impacts through provision of replacement or substitute resources that would otherwise be unavailable.

This approach was adopted after consultation with resource agencies including the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service. The following subsections provide a summary of the mitigative measures for botanical resources proposed by the Applicant as described in Exhibit E (Vol. 6A, Chap. 3, pp. E-3-250 - E-3-292).

J.3.1.1 Avoidance

Without mitigation, construction of all project facilities would remove vegetation from a total of about 44,000 acres (17,800 ha) and would remove or disturb an additional area of about 12,000 acres (4,900 ha) for transmission facilities. Removal of vegetation cannot be totally avoided; therefore, the Applicant has proposed implementation of the other mitigative measures.

J.3.1.2 Minimization

Mitigative measures proposed by the Applicant to minimize impacts to vegetation generally consist of measures applied to the design or location of project facilities so as to reduce clearing requirements or effects on sensitive areas such as wetlands. The Applicant has already applied these mitigative measures to the proposed siting and design of major facilities such as construction camps and villages, the Devil Canyon railhead facility, and general access and transmission line routing. However, these mitigative measures would also be applied on a more site-specific basis during detailed engineering and alignment studies for project facilities.

The Applicant has planned the siting of facilities to minimize impacts to vegetation where possible. The areas that would be disturbed and cleared for camps, villages, temporary roads, fuel and equipment storage areas, and other construction support facilities have been confined to the vicinity of the dam sites. The proposed locations of the permanent village and temporary construction village at Watana have been combined. The dimensions of proposed construction camps and villages have been kept small by designing compact arrays of uniformly-sized, contiguous residential modules. The consolidation of construction facilities and careful planning of traffic patterns and service roads should also minimize non-essential disturbance of vegetation by construction workers. In addition, the Applicant plans to implement an environmental briefings program that would require participation by all field personnel in order to further minimize unnecessary disturbances to soils and vegetation.

The proposed routing of the Watana-to-Gold Creek access road and transmission line right-of-way through the same general corridor should minimize vegetation removal associated with access and equipment transport to the transmission line corridor. Use of flat-tread, balloon-tire vehicles would further minimize impacts to ground layer vegetation and organic soils. The Applicant has planned use of side-borrow and balanced cut-and-fill techniques (see Exhibit E, Vol. 6A, Chap. 3, pp. E-3-264 - E-3-266) for access road construction, thereby, minimizing the need for large borrow sites located some distance away from the access corridors. Contingency borrow sites have been sited immediately adjacent to the access routes. This further reduces vegetation clearing requirements by eliminating the need for separate access roads to the borrow sites. The planned use of rail access between Gold Creek and Devil Canyon has minimized vegetation loss because the clearing width of this corridor [50 ft (15 m)] is less than half the width required for road construction [120 ft (37 m)]. The Applicant has entirely avoided siting of all pads, buildings, and other structural facilities in wet sedge-grass tundra, which is a vegetation type (and wetland community type) of relatively low abundance in the upper and middle Susitna Basin. In particular, the proposed locations of the camp, village, and other facilities at Devil Canyon have been sited to minimize impacts to wetlands in the vicinity of Jack Long Creek.

The Applicant has realigned the proposed access routes and Dams-to-Gold Creek transmission line right-of-way to avoid wetland areas and important wildlife habitat. The proposed Denali Highway-to-Watana access route has been moved westward from its original alignment to relatively well-drained terrain and soils that generally should allow side-borrow or balanced cut-and-fill construction techniques rather than the bermed construction techniques required in wet, poorly drained terrain. This realignment is shorter than the original route and, therefore, would cross fewer wet areas. Additionally, potential alterations of plant communities caused by alterations to drainage patterns and siltation would be minimized by avoiding the low, wet terrain that would have been crossed by the original alignment. Minor route adjustments have also been made to minimize potential impacts to wetland areas in the vicinity of lower Deadman and Tsusena creeks. The Applicant also has realigned the proposed rail access to Devil Canyon to minimize impacts to wetlands in the Jack Long Creek area. The alignment has been modified to follow the hillside south to Jack Long Creek rather than crossing the lower ground along the north side of the creek. The proposed railhead facility has been relocated to relatively flat ground on the south side of the creek from its original location on the north side. The proposed Dams-to-Gold Creek transmission corridor has been realigned to follow a route similar to the proposed access route in the Jack Long Creek area. The Applicant has also indicated that site-specific adjustments in access and transmission line routes would be made during detailed alignment studies to minimize wetland and floodplain crossings.

Proposed use of flexible speed designs as well as application of side-borrow and balanced cut-and-fill techniques for access road construction should reduce fill requirements, thereby, minimizing impacts to vegetation. The reduced need for separate borrow sites for side-borrow and balanced cut-and-fill construction has been discussed previously. The side-borrow technique generally only disturbs a 20 ft (6 m) strip along each side of the roadbed. Balanced cut-and-fill construction generally is only feasible where excessively deep cuts are not required to minimize grades. The proposed Watana-to-Devil Canyon access road has been routed to follow gentle to moderate slopes and where possible, to avoid deep cutting and the excessive fill requirements associated with deep cutting. Additionally, on steep terrains, use of a flexible speed design would allow use of steeper grades and shorter-radius curves that could not be accommodated by a uniform 55 mph (88 km/hr) design speed.

The Applicant has planned to minimize vegetation loss (either clearing or burial) associated with disposal of spoil created during construction activities and borrow excavations. This plan includes depositing most of the spoil produced during construction of the proposed Watana and Devil Canyon impoundments and facilities within the impoundment area in such a way that fines are prevented from becoming entrained in surface water flows during construction or turbulent flows during filling or operation. Planned access road construction techniques are not expected to produce non-usable spoil requiring separate disposal sites.

To minimize impacts to vegetation crossed by the transmission line corridors, the Applicant has planned only selective clearing of the rights-of-way. In general, clearing for guyed x-type towers up to 85 ft (26 m) tall on level terrain (see Fig. J-6) would be limited to the following:

- The maximum vegetation height would be 10 ft (3 m) on the inside buffer edge and 60 ft (18 m) on the outside buffer edge;

- A strip of vegetation not exceeding 10 ft (3 m) in height would be maintained between adjacent transmission lines except at tower sites;

- At tower sites [tower-to-tower span equals 1,200 to 1,300 ft (360 to 390 m)] transverse strips, 30 ft (9 m) in width, would be cleared between adjacent towers;

- In the area under the lines, including 5 ft (1.5 m) beyond the outside phases, trees and shrubs over 2 ft (0.6 m) tall would be cut to within 6 in (15 cm) of the ground surface and other vegetation under 2 ft (0.6 m) in height would be left uncut;

- At tower sites and in areas occupied by longitudinal access trails or by temporary construction facilities, all vegetation might be cleared, and grubbing of stumps or stripping of the organic layer would be required for tower erection at some locations;

- Outside rights-of-way, additional limited clearing would be required to allow access and to remove danger trees (trees of sufficient height to contact towers, guys, or lines if they were to fall);

- All slash, debris, and felled danger trees would be stockpiled within rights-of-way, allowed to dry through the summer immediately following clearing and control-burned at the end of the summer, in order to reduce the potential for spread of spruce budworm and other insects or disease;

- No herbicides would be used;

- Maintenance-related clearing of rights-of-way would probably be necessary about every ten years;

- Between such periodic clearing, vegetation would be allowed to grow undisturbed, except where danger tree removal is required or localized clearing is required for tower or line repair and maintenance.

To minimize clearing of vegetation for access to transmission line corridors, the Applicant has planned to require contractors to prepare access plans that are acceptable to the Applicant as well as landowners or controlling agencies. The Applicant has stated that access planning would include the following basic elements to minimize impacts to vegetation:

- Stipulation that existing roads would be used to the nearest point of transmission corridor access and that contractors obtain permission to build construction trails from the nearest points on existing roads to the rights-of-way;

- Stipulation that construction trails would be established only after thorough onsite assessment of alternative routes and development of procedures to ensure minimal environmental disturbance (including avoidance, where feasible, of dense vegetation, stream crossings, wetland and floodplain areas, and extensive switchbacks on steep erosion-prone terrain);

- Use of minimum-standard longitudinal trails from tower to tower along the cleared inside portion of the rights-of-way.

The Applicant has planned to minimize impacts to vegetation associated with increased public access to the upper and middle Susitna Basin. Along the proposed Denali Highway-to-Watana road, public access would be restricted during construction by use of a locked gate supervised by security guards. Public use of the proposed rail access would not be allowed. Policies concerning public access to the proposed project area after project construction would be developed with concurrence of land and resource management agencies and private landowners whose lands would be affected. Options to minimize public-use impacts to vegetation that would be considered include: (1) gating the proposed Denali Highway-to-Watana access road, (2) use of signs to deter vehicle departures from the road, (3) special regulatory designation of access roads to discourage off-road and all-terrain vehicle use, (4) use of regulatory options available to resource management agencies to limit access to lands under their jurisdiction, and (5) phased implementation of the Susitna project recreation plan, which is designed to minimize and localize access-related impacts through use of trails and designated camping areas, and is subject to interagency review and concurrence.

J.3.1.3 Rectification

Mitigative measures to rectify impacts to vegetation generally would be applied once project facilities used on a temporary basis during construction are no longer needed. Areas disturbed by either construction activities or nonessential activities would also require rectification. Vegetation losses or disturbance caused by building of temporary construction facilities and construction- or other human-related activities would be, at least, partially rectified by dismantling of structures; regrading, recontouring, and rehabilitating soils; and preparing soils to allow rapid reestablishment of vegetation. The Applicant has presented a general schedule for rehabilitation of major temporary facilities in Exhibit E (Vol. 6A, Chap. 3, pp.E-3-276 - E-3-278). In most cases, planned rehabilitation procedures would probably only partially rectify vegetation losses in the short term, because replacement of lost plant communities by similar community types depends upon the rate of plant succession, which may vary but could take as long as 150 years (see Section J.2.1.1.1).

The Applicant has designated the preparation of comprehensive restoration plans as a task for the detailed engineering design phase. Due to the need for site-specific rehabilitation procedures, individual restoration plans would be developed for each area requiring rehabilitation.

In general, individual plans would include information such as the following for contractors and monitors to use:

- A plan view (drawing) of the area to be rehabilitated, including clearly delineated limits, overburden or soil stockpile locations, and areas of special concern (e.g., erosion, slumping, oil saturation from equipment maintenance shops);
- Aerial photographs of the plan view area to serve as a photo base for (1) overlays of original vegetation and soil types as well as appropriate revegetation classes (Alaska Rural Development Council, 1983), and (2) overlays of areas requiring special treatment (e.g., seeding for erosion control, water bars, application of extra soil and/or organic layer material, extra or special fertilizer applications);
- Specific locations for stockpiling of organic soils, with special stipulations for providing protective measures against drying, wind erosion, and runoff;
- Specifications of depths and procedures for ripping and scarification during soil preparation;
- Specifications for quantities and types of fertilizers to be applied;
- Specifications of revegetation mixtures to be used for seeding, including application rates and planting methods.

Although specific restoration plans would provide much greater detail and might vary considerably depending on site-specific conditions, the following paragraphs give an overview of the general procedural approach planned by the Applicant.

The land surface of disturbed areas would be ripped and graded to contour. Previously stockpiled mineral and/or organic layer soils would then be spread evenly over the contoured land surface. Fertilizer high in phosphorus (e.g., 10-20-10 or 8-32-16, N-P-K) would be applied at a rate sufficient to supply about 75 to 100 pounds of nitrogen per acre (85 to 100 kg/ha).

Following the spreading of mineral soil, organic layer material, and fertilizer, the site surface would be scarified to a depth of 12 in (30 cm) using a rake towed by a mini-Rolligon-type vehicle. This procedure is intended to mix the organics with underlying mineral soil, aerate the mixture, and lightly compact the surface. During the second and third growing seasons, followup fertilizer applications would be made at one-half to one-third of the original rate.

At sites where aesthetic considerations would not be involved and the probability of erosion-related problems would be low, rehabilitation procedures would emphasize site preparation and application of organics and fertilizer but would minimize seeding. This approach should encourage the reinvasion of native species from surrounding relatively undisturbed communities. For sites where the degree of disturbance is slight and soils have remained intact, fertilization alone should be sufficient to facilitate revegetation. Sites with high erosion or visual impact potential would be seeded with fast-growing native grasses appropriate to the climate and geography of the Susitna Basin.

To minimize erosion, all sites would be physically rehabilitated, fertilized, and, seeded, if necessary, by the first-growing season following the removal of structures or equipment. The revegetation potentials of available native strains would be evaluated prior to use on disturbed sites, and sufficient quantities of seeds for those sites requiring seeding would be stockpiled. Selection of species or strains for site rehabilitation would be made after consultation with Federal and state natural resource agencies.

J.3.1.4 Reduction

Mitigative measures planned by the Applicant to reduce impacts to vegetation would really be an extension of rectification in that these measures would mainly involve monitoring of project facilities and activities to ensure the most effective use and application of rehabilitation measures. The Applicant plans to conduct the following tasks on a continuing basis during project construction and operation:

- Monitor rehabilitation progress to identify sites or locations within sites requiring repeated or altered applications of fertilizer and/or seed;
- Systematically identify disturbed areas where construction activities have ceased and which are no longer required, and initiate rehabilitation;
- Coordinate rehabilitation efforts with closure and removal of service or temporary roads identified as no longer required.

These measures would be stipulated in the comprehensive restoration plans and would be intended to help focus and implement the plans.

A major objective of the monitoring program would be to maintain awareness of the extent and location of disturbed areas, both planned and unplanned, so that rehabilitation could begin as early as feasible once activities in a given area diminished. Monitoring would be used throughout pre-construction field activities and the construction and operation periods to identify areas in need of rehabilitation other than those specifically targeted in the original comprehensive restoration plans.

J.3.1.5 Compensation

Since the proposed dam and impoundment sites are essentially fixed, vegetation lost due to their construction could not be minimized, rectified, or reduced over time. These vegetation losses could only be offset through compensation measures. The Applicant has considered two compensation options:

- Acquisition of lands with areal coverages of vegetation types equivalent to those lost, and protection of these lands from future development;

- Prioritization of lost vegetation types with respect to their value as wildlife habitat followed by selective alteration of vegetation on acquired lands to replace or exceed lost areal coverages of high-priority vegetation types.

The second option has been selected by the Applicant because habitat enhancement measures accomplished through vegetation alteration would allow compensation for high-priority vegetation (habitat) types while requiring acquisition of relatively smaller land areas.

In identifying replacement lands for habitat enhancement, the Applicant would place the highest priority on state and Federal lands that can be acquired at minimal or no cost. Alaska Department of Natural Resources (ADNR) statutes (Title 38) set forth provisions for exchanges of state-owned lands on an equal-value basis following appraisal. Black spruce forest types, which are considered to have high enhancement potential, are readily available on state-owned lands in the vicinity of the proposed Susitna project. Thus, the Applicant anticipates that replacement lands might be acquired through exchanges of state lands following ADNR review and concurrence. A second possibility for replacement land acquisition being considered by the Applicant is provided by Section 907 of the Alaska National Interest Lands Conservation Act of 1980 (Publ. L. 96-487). This provision established the Alaska Land Bank Program, which affords private landowners tax incentives and other benefits for making lands available for fish and wildlife management in accordance with the policies of state or Federal resource agencies.

To help assess the suitability of controlled burning as a method for browse habitat enhancement, the Applicant has participated in a cooperative program with the U.S. Forest Service Institute of Northern Forestry, the Alaska Department of Fish and Game, and the Bureau of Land Management. To date, species distribution, abundance, and vegetative cover have been quantified within the 6,400-acre (2600-ha) Bureau of Land Management area that has been designated for controlled burning in the Alphabet Hills east of the project area (Steigers et al., 1983). After the area is burned, studies would be conducted to characterize post-burn plant succession and browse availability. Other aspects of the Applicant's mitigation plan with regard to compensation of lost wildlife habitat are described in Section K.4.1 of Appendix K.

J.3.2 <u>Evaluation of Proposed Measures</u>

Resource agencies' formal comments on the proposed mitigation plan, in general, have supported the approach taken by the Applicant for mitigating vegetation losses. Agency comments are generally critiques of the proposed plan rather than recommendations of totally new measures. The Staff also agrees with the general approach to mitigation proposed by the Applicant.

The U.S. Fish and Wildlife Service in particular, has expressed concern that the proposed mitigation plan is incomplete and too general. Specific concerns have been outlined by the U.S. Department of the Interior (1983). The Applicant, however, has responded (Alaska Power Authority, 1984a) that mitigation plans would be updated and refined as more complete data and further analyses are obtained. Furthermore, the Applicant has indicated awareness of the need for stipulating more specific procedures, locations, schedules, and costs, but has deferred many site-specific aspects of mitigation planning until the detailed design phase of the proposed project development.

Several agencies, notably the U.S. Fish and Wildlife Service (U.S. Dept. of Interior, 1983) and the Bureau of Land Management (U.S. Dept. of Interior, Bureau of Land Management, 1983), have recommended (1) that the Applicant continue to consult closely with state and Federal resource agencies as the mitigation plan is refined, and (2) that impacts to vegetation, implementation of mitigative measures, and the efficacy of mitigative efforts be monitored by an interagency monitoring team. The Staff concurs that such interaction with resource agencies is necessary, and the Applicant has also acknowledged the necessity of interaction.

There is some concern on the part of the agencies with regard to feasibility of the proposed compensation measures. The state of Alaska (State of Alaska, Office of Management and Budget, 1983) has expressed concern that habitat enhancement efforts could be risky and, therefore, favors compensation with replacement lands. Conversely, the U.S. Fish and Wildlife Service (U.S. Dept. of Interior, 1983) has indicated support for the Applicant's chosen option of compensation through habitat enhancement, but noted that selection and development of lands for habitat enhancement must also include consideration of other habitat characteristics affecting wildlife habitat values, including (1) location with respect to wildlife-use patterns and (2) interspersion with vegetation types providing cover and protection.

There is also concern on the part of the agencies and the Staff about the feasibility and specifics of habitat-enhancement measures. Although it is fairly well documented that disturbances such as fire generally effect an increase in browse production (Wolff, 1978; Wolff and Zasada, 1979; Viereck and Schandelmeier, 1980), there are uncertainties as to selection of methods and the specific effects of factors such as soil and environmental conditions, the species composition of vegetative communities to be modified, and the composition of surrounding communities. Thus, at present it would be difficult in many locations to predict with confidence the precise results of enhancement manipulations on changes in vegetative community structure and productivity. Furthermore, it would be even more difficult to predict the responses of wildlife populations to various enhancement manipulations. Therefore, several agencies have indicated that additional studies are required to determine more precisely (1) what important habitat areas would be lost due to construction and operation of the proposed project, (2) whether it is possible or feasible to replace these areas, and (3) how and where to best attempt replacement manipulations. It is for these reasons that resource agencies have recommended vegetation and wetland studies and mapping that are oriented towards quantification and understanding of plant communities from a wildlife habitat perspective. The Applicant has acknowledged these concerns and has stated that efforts are being made to pursue such studies with the help and consultation of appropriate resource agencies during the mitigation plan refinement process (Alaska Power Authority, 1984a,b).

Concerning the Applicant's approach to rectification of vegetation impacts, the agencies and the Staff concur with the general rehabilitation procedures proposed by the Applicant, recognizing that more specific details of procedures, locations, schedules, and costs are planned for the detailed design phase of the proposed project development and should also be covered in greater detail in the Applicant's planned Revegetation/Rehabilitation Manual. However, the Staff recommends that the Applicant, where feasible, consider the use of engineering practices to stabilize erosive areas either in addition to or in lieu of seeding with native grasses. For example, terracing would not only reduce erosion but would help collect moisture which may be critical to rapidly achieving successful revegetation. As another example, properly placed water-control diversions would minimize erosion while allowing surface drainage of excess water. Since seeding with grasses (even native species) might inhibit later invasion by other native species, the judicious use, where feasible, of such erosion-control measures in lieu of or to minimize seeding with grasses might allow development of a more typical native community than would otherwise occur.

J.3.3 Recommended and Ongoing Studies

The Staff recommends that ongoing studies oriented towards quantification and understanding of plant communities from a wildlife habitat perspective as well as those designed to evaluate the responses of plant communities and wildlife populations to various habitat manipulation options be completed. These studies should include direct mapping of wetlands for all areas that would be affected by construction and operation of the proposed project (including the Healy-to-Willow transmission line segment) using classification categories specific enough to assess losses of high-value wetland types.

The Staff also recommends that studies be conducted to determine the effects of long-term (five to ten years) soil storage on rehabilitation success. Although there is evidence that replacement of mineral and/or organic-layer soils can significantly improve revegetation of disturbed sites (Van Cleve, 1978; Chapin and Chapin, 1980; Johnson, 1981; Gartner et al., 1983), long-term storage of soil (mineral or organic-layer) could affect seed or vegetative propagule viability and/or the chemical, physical, and microbial properties of the soil. These effects could reduce rehabilitation success compared to areas where replaced soils were stored for less than a year or two (Hinchman et al., 1981; Miller et al., 1981, 1984). Even more importantly, it should be determined whether specific storage methods or practices (e.g., controlling moisture content or compaction levels, depth of stockpiles, or mixture of organic and mineral soils) can enhance the potential for rehabilitation success when replacement soils must be stored for long periods.

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DRAFT ENVIRONMENTAL IMPACT STATEMENT

SUSITNA HYDROELECTRIC PROJECT, FERC NO. 7114

APPENDIX K

TERRESTRIAL WILDLIFE RESOURCES

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APPENDIX K. TERRESTRIAL WILDLIFE RESOURCES

K.1 BACKGROUND

The diversity of plant associations within Southcentral and Interior Alaska (see Appendix J) provides habitat for a large array of animal populations. The study area supports populations of big game (e.g., moose, Dall's sheep, barren-ground caribou, black and brown bear), furbearers (e.g., wolverine, wolf, fox, beaver, marten), migratory waterbirds, raptors, and numerous other small mammals, birds, and invertebrates (Selkregg, 1974, 1977; Alaska Dept. of Fish and Game, 1973, 1978). Reptiles and amphibians are generally not found in the project area because of the extreme latitudes, although the wood frog may be present (Hodge, 1977).

The complex interactions of animal populations within subarctic ecosystems make it difficult to quantify the importance of any given population of wildlife. The number of populations found in subarctic ecosystems makes it necessary to place priorities on their consideration, thus emphasizing some taxa at the expense of detailed consideration of other taxa. This approach has been reflected in the applicant's Exhibit E* (Vol. 6A, Chap. 3, pp. E-3-294 to E-3-296), as well as in the U.S. Fish and Wildlife Service's (1983a) identification of "mitigation evaluation species".

In general, the degree of emphasis on given wildlife taxa has been directly proportional to the anticipated magnitude of impact and extent of their use by humans in the project area (Table K-1). Hence, moose and other big game species are emphasized throughout the following discussions, and furbearers are given less attention. In addition, emphasis is placed on certain taxa because of their high national interest, e.g., bald and golden eagles, trumpeter swans, and other waterbirds. Small mammals and birds are treated less intensively because they are not generally used by humans in the project area and detailed ecological data are less available. Invertebrate populations are not treated because of the paucity of data available to relate project impacts to the dynamics and structure of these populations. At this time, no taxa of small mammals, birds, or invertebrates are known to have significantly broad ecological value to subarctic ecosystems that might be impacted by the proposed project.

In the succeeding discussions, emphasis is placed upon the location of wildlife concentrations and the distribution of important habitat in relation to project features. Numerical estimates of some wildlife populations are available for the project area. However, these estimates are based upon necessarily limited sampling efforts and are characterized by broad ranges of statistical uncertainty. Therefore, principal emphasis is placed upon habitat features that might be altered by the construction and operation of the proposed project. These features include areas of winter forage and shelter, breeding and rearing areas, migratory pathways, and mineral licks. This approach is in keeping with current philosophies in regard to the assessment of impacts to and development of mitigation programs for wildlife populations (Schweitzer et al., 1978; U.S. Fish and Wildlife Service 1980, 1981, 1983a; Mautz, 1980; Wolfe, 1980; U.S. Dept. of Energy, 1982).

In the course of preparing its application to the Federal Energy Regulatory Commission, the Applicant has sponsored and continues to sponsor a series of studies of the biology of wildlife in the Susitna River Basin (Exhibit E, Vol. 6A, Chap. 3, Sec. 4). The principal organization carrying out these studies was the Alaska Department of Fish and Game (ADFG). Each individual researcher defined a study area based upon the taxa under study and the scope of the study. The discussion herein is based upon the results of those studies, as well as upon other studies in Southcentral Alaska and current knowledge of the biology of relevant wildlife species. Use of the term "study area" in this analysis refers to the area studied by the researchers under discussion, and the geographical extent of that area differs among studies. As used in this analysis, the term "project area" is used to designate that area adjacent to project features such as dams, reservoirs, access routes, or power transmission lines.

In the discussions that follow, nomenclature follows Hall (1981) for mammalian taxa and the American Ornithologists' Union (1975) for avian taxa.

*Throughout this document, references to specific "Exhibits" are to the exhibits submitted to FERC as part of Alaska Power Authority's Susitna Hydroelectric Project License Application. References to specific "Appendices" (App.) are to the appendices provided in Volumes 2 through 7 of this Draft Environmental Impact Statement.

Table K-1. Taxa of Wildlife Considered in Assessment of Impacts from Susitna Hydroelectric Project

Colloquial Name†[1]	Scientific Name†[1]	Reason for Consideration
Moose*†[2]	Alces alces	Major big-game species in study region
Alaskan barren-ground caribou*	Rangifer tarandus granti	Big-game species; high public interest; unique to Alaska in United States
Dall's sheep*	Ovis dalli	Big-game species; unique to Alaska in United States
Brown bear*	Ursus arctos	Big-game species; high national interest; nationally scarce
Black bear*	Ursus americanus	Big-game species
Beaver*	Castor canadensis	Important furbearer
Pine marten*	Martes americana	Important furbearer
Gray wolf*	Canis lupus	Furbearer; major predator on game species; high national interest; nationally scarce
Other furbearers	Orders Carnivora and Rodentia, in part	Harvested on limited scale in project area
Other mammals	--	Components of subarctic ecosystems
Golden eagle*	Aquila chrysaetos	High national interest
Bald eagle	Haliaeetus leucocephalus	High national interest; nationally scarce
American peregrine falcon	Falco peregrinus anatum	Endangered species
Other raptors	Order Falconiformes, in part	High national interest
Trumpeter swan*	Olor buccinator	High national interest; nationally scarce
Other waterfowl and waterbirds	--	High national interest
Other birds	--	Components of subarctic ecosystems

†[1] Mammalian nomenclature follows Hall (1981); avian nomenclature follows American Ornithologists' Union (1975).

†[2] Taxa designated by an asterisk (*) are nominated by U.S. Fish and Wildlife Service (1983a) as "mitigation evaluation species" for the Susitna Hydroelectric Project.

K.2 AFFECTED ENVIRONMENT

K.2.1 Proposed Project

K.2.1.1 Upper and Middle Susitna River Basin

K.2.1.1.1 Moose

Moose (Alces alces) are the principal species of big game throughout the Susitna Basin (Selkregg, 1974; U.S. Dept. of Agriculture, 1981). This largest of the deer family is a characteristic inhabitant of the boreal or northern forests (Franzmann, 1980; Coady 1982). Moose are primarily browsers, feeding on shrubs and trees, especially during the winter months when herbaceous forage is generally unavailable. During the summer months, moose forage includes grasses, forbs, emergent aquatics, and mosses. Peek (1974) concluded that willows formed the chief component of the Alaskan moose diet, although diet varies with availability of forage species. Stands of early stages (less than 25 years) in boreal forest succession are considered major sources of winter browse for Alaskan moose populations (Wolff and Zasada, 1979; Franzmann, 1980; Coady 1982).

CONDITION OF POPULATION

Based upon a stratified censusing survey conducted in November 1980 by Ballard et al. (1982a), the Applicant estimated that about 4,000 moose occurred within the 2,200 square miles (mi^2) [5,700 square kilometers (km^2)] that were surveyed around the proposed impoundment area (Exhibit E, Vol. 6A, Chap. 3 p. E-3-311). Ballard et al. (1983a) estimated that over 11,000 moose inhabited about 5,400 mi^2 (14,000 km^2) surrounding the project area. Historically the moose population in the basin has been on the decline since 1962, with indices of productivity reaching a low around 1975 (Bishop and Rausch, 1974; Ballard et al. 1982a, 1983a). Productivity appears to have stabilized or even increased within the census areas since 1975.

Bishop and Rausch (1974) suggested that moose population size was limited by a combination of predation and hunting in the Nelchina-Upper Susitna Basin, the ADFG's Game Management Unit 13, which includes the upper and middle Susitna Basin. Ballard and coworkers (Ballard et al., 1981a, 1982b) indicated that low productivity of the moose population currently is associated with low calf survival (45% to 55%) prior to the onset of winter. Predation appears to be the major factor in moose calf mortality. Bishop and Rausch (1974) suggested that wolf were the principal predators on moose in the Nelchina-Upper Susitna Basin. This appears to be true elsewhere in Alaska (Gasaway et al., 1983). However, recent experimental reductions in brown bear populations indicate that, currently, brown bear are the principal limiting predators upon moose in the Nelchina-Upper Susitna Basin (Ballard et al., 1981b; Gasaway et al., 1983). Black bear and wolf also prey on moose to a more limited extent.

Although data of Ballard et al. (1982a) indicate that predation may be an important factor in post-partum survival, it does appear likely that the severity of winter also is a factor affecting parturition and post-partum survival, as well as adult nutrition and survival (Franzmann, 1980; Coady, 1982). Nutritional stress and mortality tend to be correlated with winter severity, especially in relation to snow depth. Deep snow both reduces the availability of forage and increases the energy costs of movement and feeding. Thus, availability of overwintering forage can limit the size of ungulate populations, including moose (Coady, 1974, 1982). Population limits imposed by winter forage availability are often taken as defining the carrying capacity for ungulates on a given range (Mautz, 1980).

Although moose populations in the Susitna Basin apparently are regulated at a level below carrying capacity by predation and hunting (Bishop and Rausch, 1974; Ballard et al., 1981a,b, 1982a,b, 1983a; Gasaway et al., 1983), potential carrying capacity within the basin could be affected by the proposed project. Based upon preliminary estimates of forage availability (Exhibit E, Vol. 6B, Chap. 3, Table E.3.92) and a moose forage intake rate of 11 lb (5 kg) per day (Gasaway and Coady, 1974), the 6,300-mi^2 (16,000-km^2) Susitna Basin above Gold Creek has potential winter carrying capacity for about 12,100 moose (Table K-2). It was assumed for this estimate that severe winter conditions persist for 90 days. This duration is based upon when moose in the basin and elsewhere tend to move into winter concentrations (Telfer, 1970; Peek et al., 1971; Ballard et al., 1982a, 1983a). Were severe winters to last longer, potential carrying capacity would be proportionately lower. In addition, the carrying-capacity estimates were based on the assumption that woodland habitats would provide the majority of forage during the severe winter (see discussion below on winter habitat use). In milder winters and where forage is more readily available, potential carrying capacity would be higher for a given year.

DISTRIBUTION AND HABITAT USE

Moose are widespread over the upper and middle Susitna Basin, ranging across all habitat types in the project area. Ballard et al. (1982a) have defined 13 subpopulations of moose in the vicinity of the project. Definition of these subpopulations was based upon general patterns of

Table K-2. Estimated Potential Winter Carrying Capacity for Moose in the Projected Watana Impoundment Zone and Susitna River Basin Upstream of Gold Creek

	Area (mi^2)		Potential Winter Carrying Capacity†[1]	
Habitat Type	Impoundment Zone	Basin	Impoundment Zone	Basin
Open coniferous forest†[2]	15	460	260	6,400
Woodland coniferous forest†[3]	20	730	110	4,200
Open mixed forest†[4]	5	90	110	1,800
Other†[5]	20	5,020	-	-
Totals	60	6,300	480	12,400

†[1] Number of moose; based upon a limiting harsh winter period of 90 days.

†[2] Carrying capacity of about 240 moose-days/100 acres (Exhibit E, Vol. 6B, Chap. 3, Table E.3.92).

†[3] Carrying capacity of about 80 moose-days/100 acres (Exhibit E, Vol. 6B, Chap. 3, Table E.3.92).

†[4] Carrying capacity of about 270 moose-days/100 acres (Exhibit E, Vol. 6B, Chap. 3, Table E.3.92).

†[5] The limiting conditions of the harsh winter are based on the assumption that open habitats are not available to moose due to heavy snow.

Conversion: To convert square miles to square kilometers, multiply by 2.59.

moose movement and population concentrations (Figs. K-1 and K-2). In general, moose are most abundant in this area between Devil and Deadman creeks and east of Watana and Kosina creeks (Fig. K-2). Moose tend to use a broader array of habitats during summer than during winter (Coady, 1982). Seasonal migrations result in differential use of habitats and areas within the basin during different periods of the moose life history.

Calving in the upper and middle Susitna River Basin occurred generally in May and June during the years from 1977 to 1981 (Ballard et al., 1982a, 1983a). During calving, moose tended to concentrate along the major drainages in the basin (Fig. K-3). Calving occurred throughout the proposed impoundment and adjacent areas from Devil Creek to the mouth of the Oshetna River. During calving, moose were observed at lower elevations [ca. 2,600 feet (ft), or 790 meters (m), Mean Sea Level (MSL)] than during other stages of the life history. At this stage, moose were principally in areas dominated by sparse to medium-dense, medium-height spruce and upland brush/willow habitat types (Exhibit E, Vol. 6B, Chap. 3, Tables E.3.87 and E.3.88). These areas provide high-quality forage in the early spring as temperatures rise and the snows recede. This is particularly important after severe winters when nutritional balance must be recovered quickly for successful parturition and early rearing (Coady, 1982).

During the post-partum, rearing season (June through August) moose were observed at somewhat higher elevations [2,750 ft (850 m) MSL] than in the spring, most frequently in areas dominated by sparse to medium-dense spruce habitats (Ballard et al., 1982a, 1983a). During summer, moose tended to be more dispersed and used a greater variety of habitats than in spring.

During fall rutting or breeding season (September to October), moose tended to congregate in upland areas removed from the projected area of inundation and project feature location (Fig. K-4). Higher elevations were used at this time [averaging near 3,000 ft (900 m) MSL], and moose were observed in upland brush/willow habitat 25% and 43% of the time in September and October, respectively (Exhibit E, Vol. 6B, Chap. 3, Tables E.3.87 and E.3.88). Use of spruce habitat was concomitantly reduced in fall.

During the winters of 1977-1981 moose tended to remain at higher elevations, 2,800 to 3,000 ft (850 to 900 m) MSL (Exhibit E, Vol. 6B, Chap. 3, Table E.3.87). Use of upland brush/willow habitat remained high; 30% to 45% of moose observations occurred in this habitat November through February (Exhibit E, Vol. 6B, Chap. 3, Table E.3.88). From 1977 to 1981, few moose were observed in the bottomlands of the Susitna River (Ballard et al., 1982a). This is in contrast to earlier studies when lowlands were used during winter months. The differences may be related to the

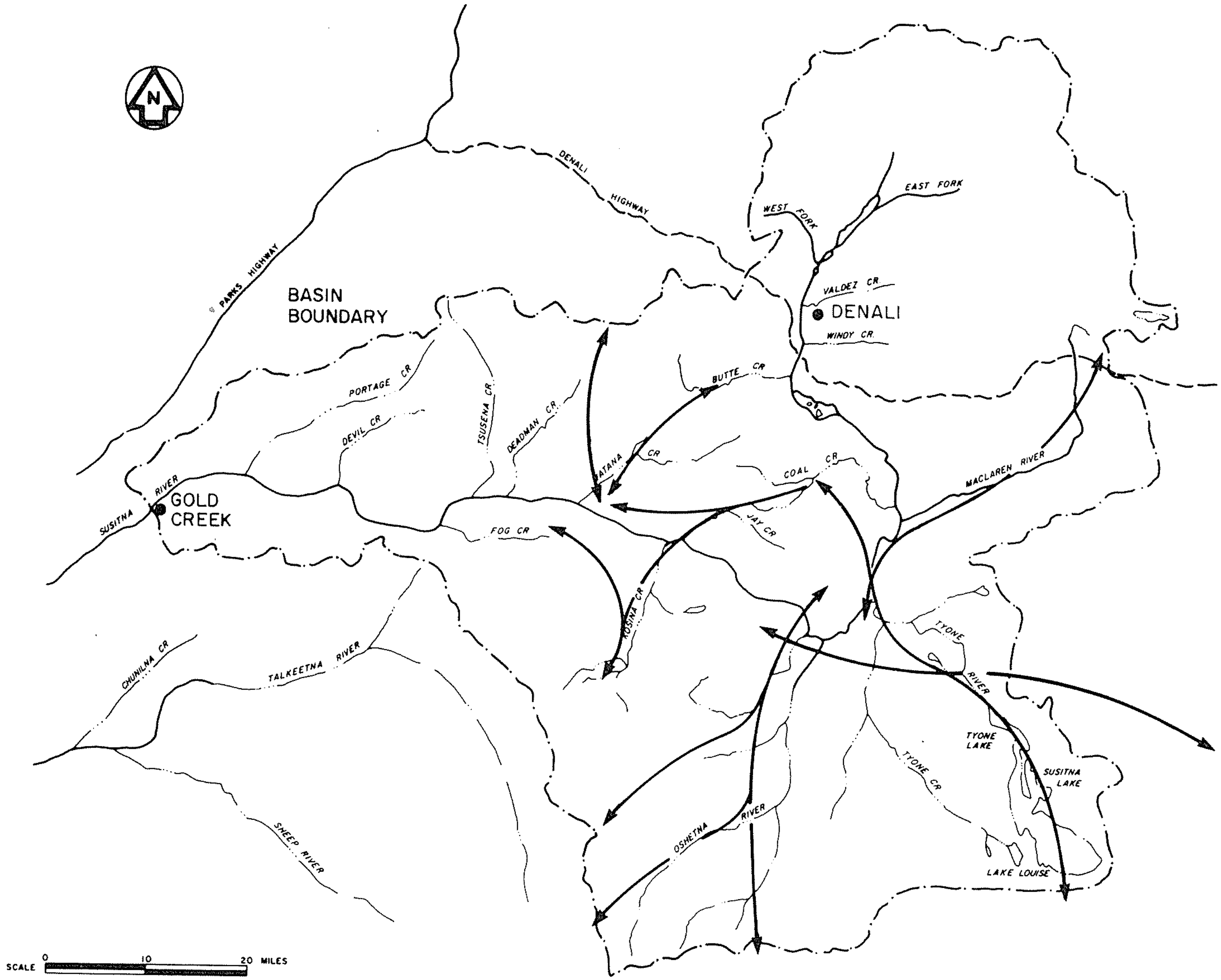

Figure K-1. General Patterns of Movement by Radio-Collared Moose from October 1976 through Mid-August 1981 within the Upper/Middle Susitna Basin. [Source: Ballard et al., 1982a: Fig. 11]

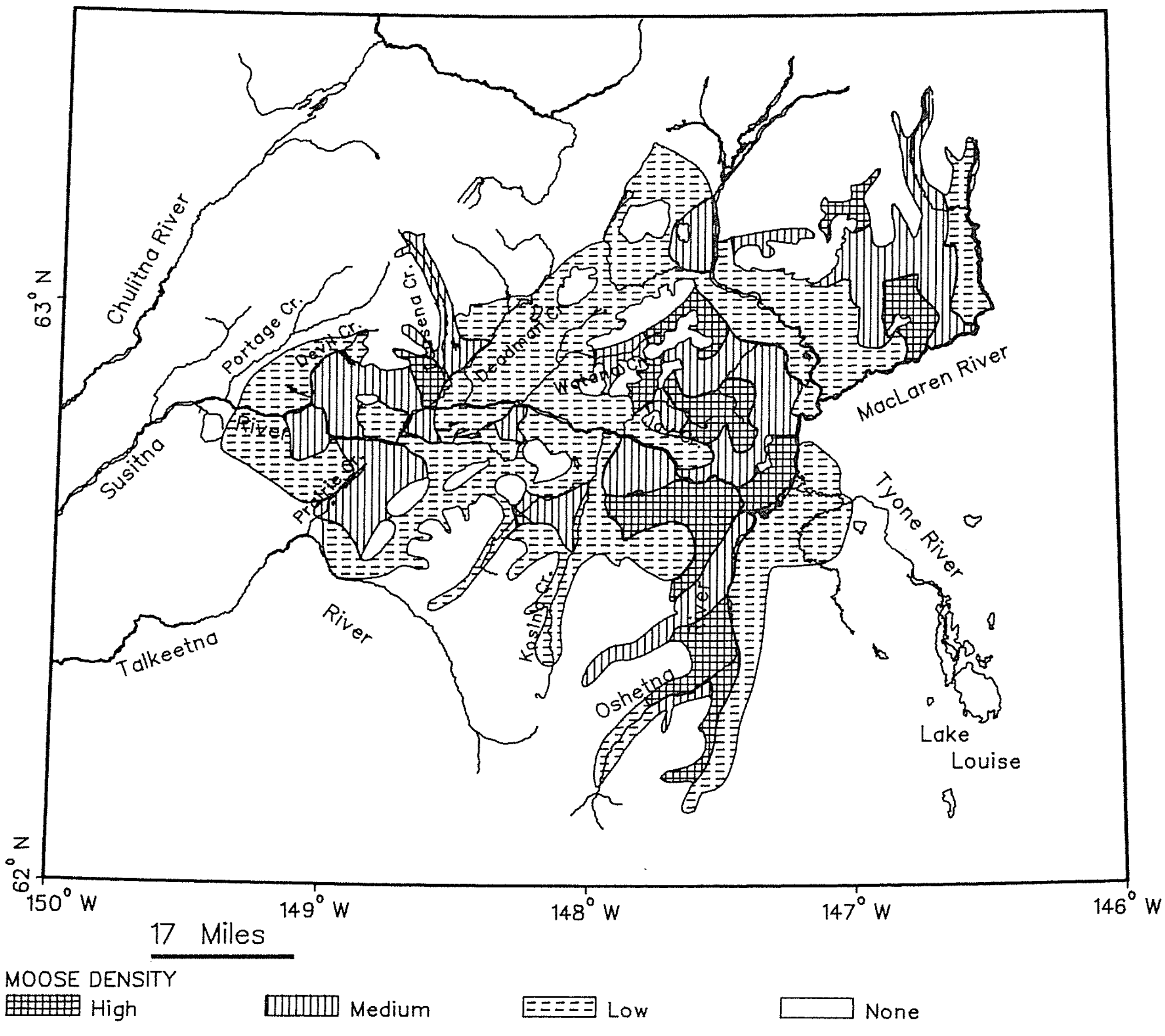

Figure K-2. Relative Densities of Moose in Census Areas within the Upper/Middle Susitna Basin. [Source: Ballard et al. 1982a: Fig. 18]

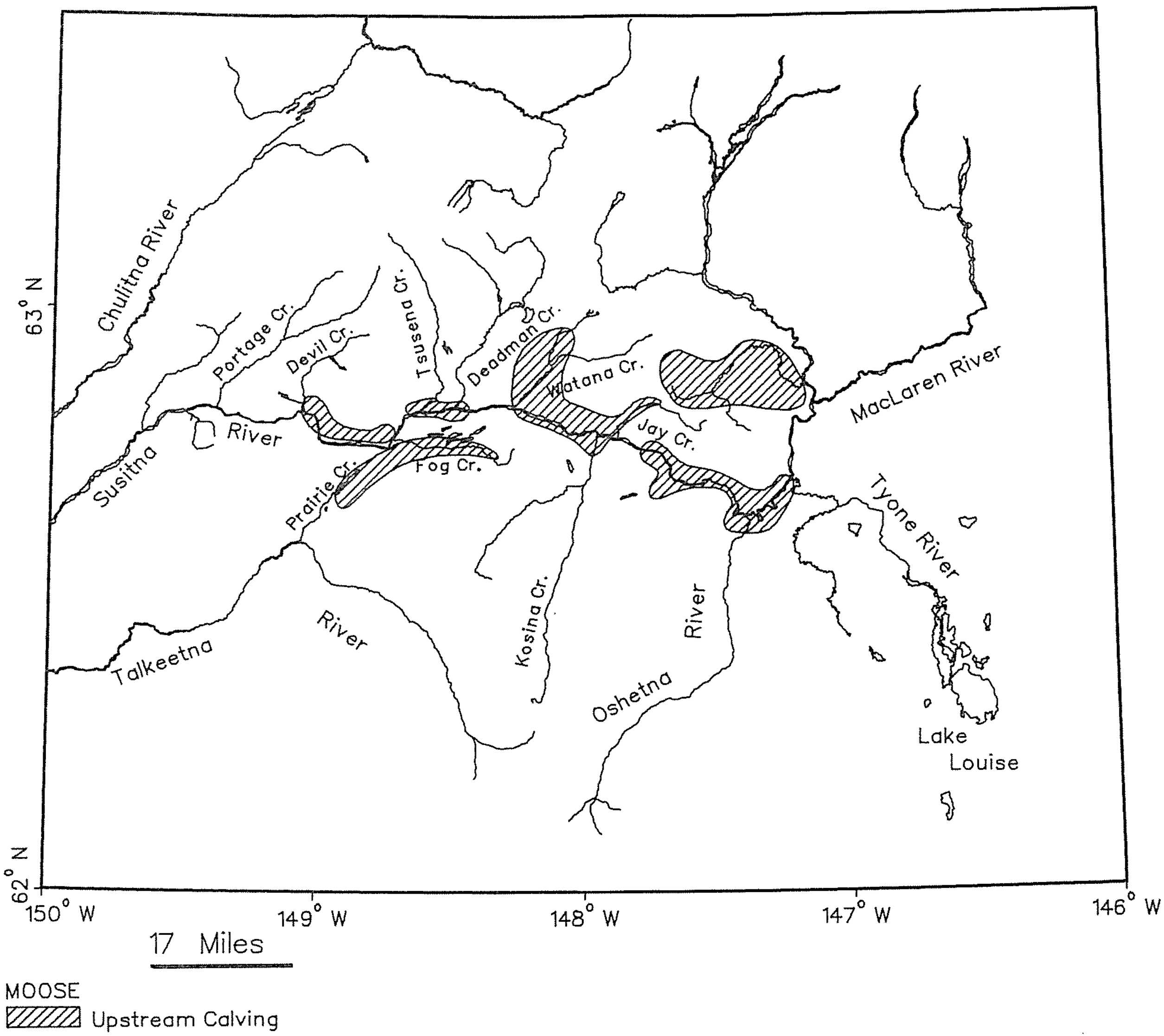

Figure K-3. General Moose Calving Concentrations (May 15 - June 15) from 1977 through 1981 in the Upper/Middle Susitna Basin. [Source: Ballard et al., 1982a, 1983a]

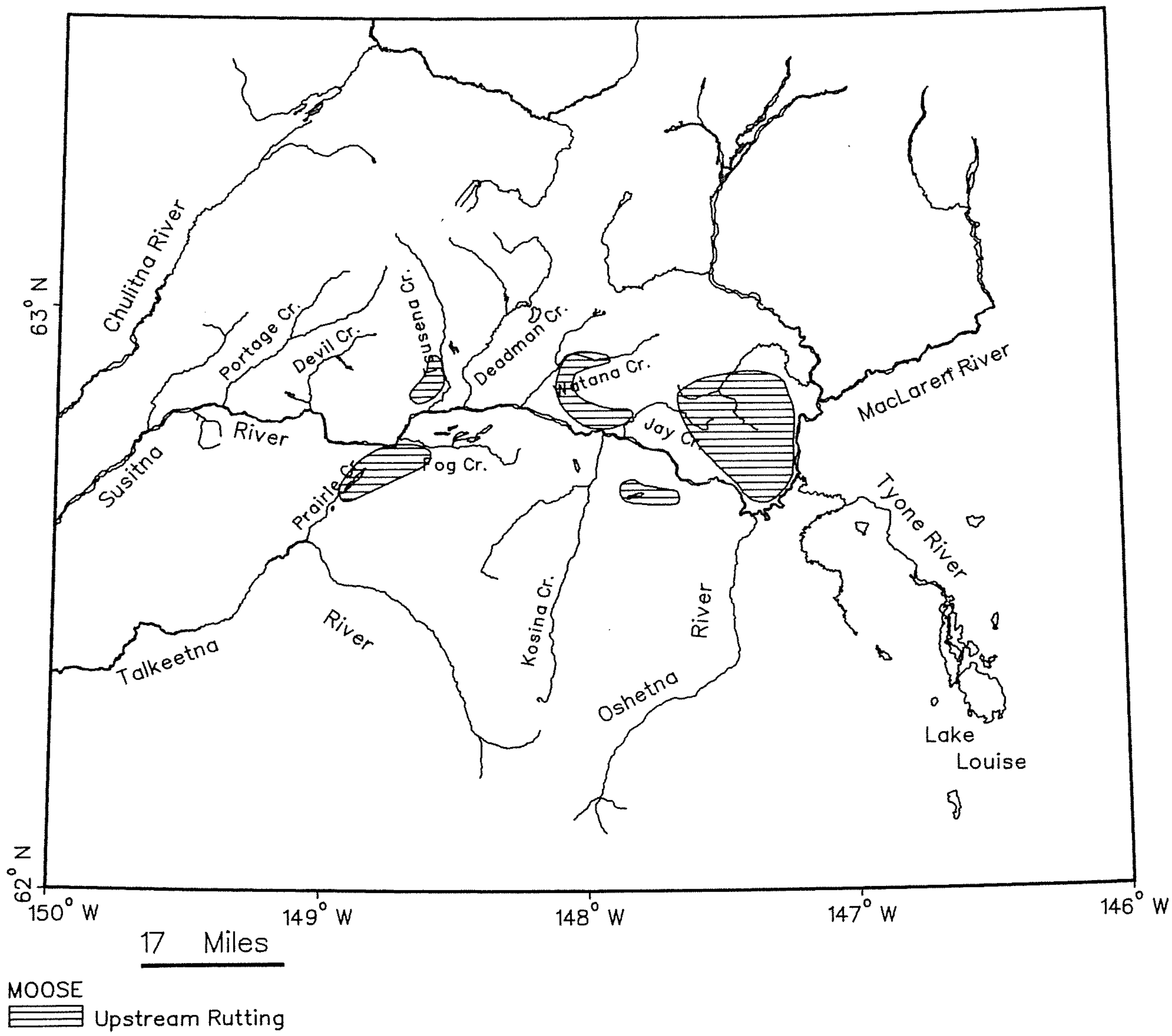

Figure K-4. General Moose Rutting Range (September 20 - October 20) from 1977 through 1980 within the Upper/Middle Susitna Basin. [Source: Ballard et al., 1982a, 1983a]

milder winters, and hence greater availability of browse in the windblown uplands, during the more recent studies.

Current studies have not permitted evaluation of the extent of limiting winter habitat in the basin (Ballard et al., 1982a, 1983a). However, earlier studies suggest that during winters with heavy snowfall, the local moose use the mixed woodlands at lower elevations along the river and its major tributaries (Exhibit E, Vol. 6A, Chap. 3, p. E-3-399).

Studies elsewhere have shown that moose tend to congregate in relatively small areas of suitable habitat during harsh winters (Telfer, 1970; Proulx and Jouyal, 1981; Proulx 1983). Moose tend to prefer habitats with dense cover for protection and with suitable browse. Such conditions are often found in mixed forests of coniferous habitat interspersed with early successional shrub or hardwood habitat (Peek et al., 1976; Stevens, 1980; Telfer, 1970, 1978; Brusnyk and Gilbert, 1983). Based upon these studies, it is likely that the mosaic of spruce and mixed woodland forest along the bottomland of the Susitna River and its tributaries provides important habitat during severe winters. Ballard et al. (1983a) did find moose concentrating along the river and major tributaries during March 1982 (Fig. K-5), and also noted that during winter moose used elevations of 3,000 ft (900 m) or higher less than would be expected on the basis of the availability of upland habitat.

In late winter through early spring of 1977 through 1981, moose tended to move to lower elevations. During March through May, use of upland brush/willow was at its lowest level of the year

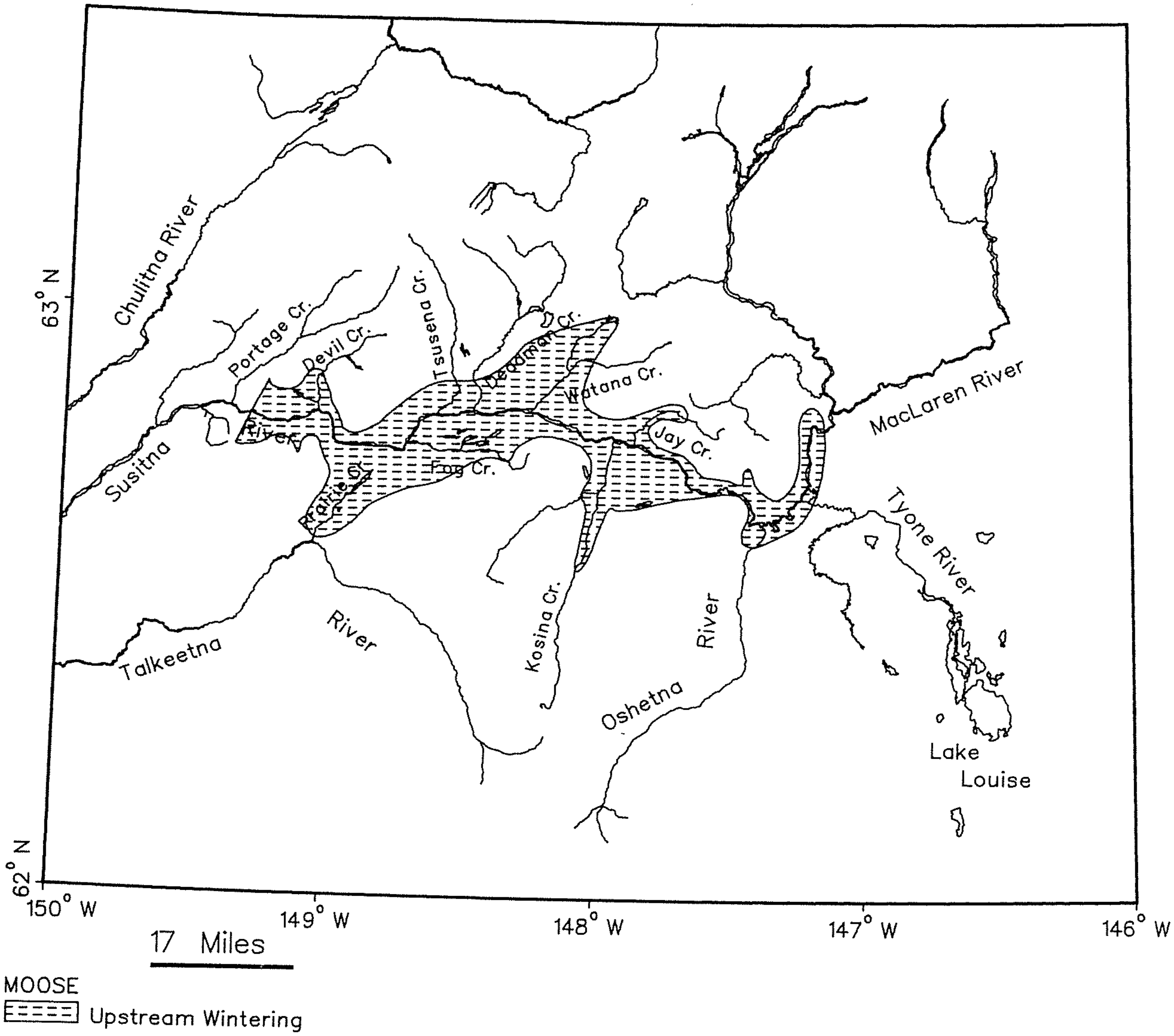

Figure K-5. General Area of Winter Range of Moose [el. <3,000 ft (900 m) MSL] from 1977 through 1982 within the Upper/Middle Susitna Basin. [Source: Ballard et al., 1982a, 1983a]

(Exhibit E, Vol. 6B, Chap. 3, Tables E.3.87 and E.3.88). Lower elevations nearer the river and the tributaries may be selected because of early availability of green forage.

MOVEMENTS

Movements of moose include local, short-distance travel within seasonally used range, longer migrations between seasonally used range, and long-distance dispersal to other regions (Coady, 1982). Local travel is principally a means of acquiring forage or taking advantage of cover on the local range. Migratory movement is generally implemented in response to varying quality and availability of forage among seasons and in response to varying weather patterns. Some, but not all, moose in a population may make traditional seasonal use of some areas and follow traditional, general patterns of migration. Dispersal is a mechanism for exploiting new range that may be underexploited.

The seasonal shifts in habitat usage by some moose necessitate movements of several miles. Ballard et al. (1982a, 1983a) indicated that migratory moose occur largely east of Jay Creek and in the area of Watana Creek (Fig. K-1). A number of migration patterns require that moose cross the Susitna River in the projected Watana impoundment area or pass near that area (Fig. K-1).

Ballard et al. (1982a: Fig. 12) reported that 28 of 73 crossings of the river (ca. 35%) from 1976 to 1980 occurred within the projected impoundment area. From 1980 to 1981, 75 moose crossed the river in the projected impoundment area a total of 40 times. Tracking data suggested that river crossings occurred throughout the affected stretch of the river, but tended to be concentrated in the following areas: Fog Creek to opposite Stephan Lake, Deadman Creek and upstream 5 miles (mi) [8 kilometers (km)], Watana to Jay Creeks, and from Goose Creek to Clearwater Creek (Ballard et al., 1982a). The population of moose along the mainstem Susitna River may also provide recruitment for more peripheral populations via dispersal (Ballard et al., 1982a, 1983a).

K.2.1.1.2 Barren-Ground Caribou

Barren-ground caribou (*Rangifer tarandus*) are members of the deer family that are characteristic inhabitants of the Arctic tundra of North America (Bergerud, 1980; Miller, 1982). Caribou tend to be highly gregarious; historically, during the post-calving period, herds have been composed of tens of thousands of individuals. Caribou forage on a broad variety of plants that includes grasses, sedges, forbs, and shrub. Mosses and lichens also form a major component of the caribou diet.

The basin surrounding the projected impoundment areas is occupied by the Nelchina caribou herd, which ranges over an area of about 20,000 mi^2 (50,000 km^2) bounded by the Alaska Range to the north, the Wrangell Mountains to the east, the Chugach Mountains to the south, and the Talkeetna Mountains to the west (Pitcher, 1982). This herd is important to sport and subsistence hunters because of its large size and proximity to Alaska's major population centers.

CONDITION OF POPULATION

Herd size has declined substantially since 1955, when an estimated 40,000 individuals comprised the herd (Hemming, 1971; Pitcher, 1982: Table 13). By the mid-1970s the herd size was below 10,000 individuals. Since then, the herd has grown to 20,000 individuals or half its 1955 size. Since the mid-1970s, the ratio of calves to females has increased from 30% to 40%, indicating increased productivity as a result of increased birth rate or decreased mortality rate. About half the mortality was attributed to predation (principally wolf) and hunting by Pitcher (1982, 1983). The balance of the mortality can be attributed to starvation, disease, aging, and accidents. Although availability of forage is the ultimate factor limiting the herd size, predation and hunting are the likely proximate limiting factors. This has been shown to be the case north of the Alaska Range (Gasaway et al., 1983).

Pitcher (1982, 1983) identified several subherds within the range of the Nelchina caribou herd. Of principal interest in relation to the proposed project is the Upper Susitna-Nenana subherd. This subherd ranges south from the Nenana River, extending east from around the Parks Highway to the headwaters of the Susitna River. Pitcher (1983) estimated that about 2,000 individuals composed this subherd.

DISTRIBUTION AND HABITAT USE

During the calving period (May-June) in 1980-1982, the females of the main herd occupied the drainages of Kosina Creek, Goose Greek, and Oshetna River (Fig. K-6). Historically, the herd's calving grounds have ranged from Fog Lakes to the Little Nelchina River in the northern Talkeetna Mountains, at about 3,000 to 4,500 ft (900 to 1,400 m) elevation (Pitcher, 1982). The habitat used by females during calving was predominantly herbaceous-tundra. Calving concentrations of the Susitna-Nenana group occurred at the headwaters of the Chulitna River, from Coal Creek to upper Deadman Creek, and at the headwaters of the Susitna River (Fig. K-7). Males tended to remain in the wintering areas dominated by spruce forest.

During summer, males tended to occur at lower elevations [ca. 3,500 ft (1,000 m) MSL] than did females [over 4,000 ft (1,200 m) MSL]. Historically, the female-calf segment of the main herd has spent the summer in the eastern Talkeetna Mountains and across the Susitna River from Deadman Creek, near the calving range (Fig. K-6). Males have summered dispersed throughout the range of the main herd. The subherd also summered near the calving range, but at higher elevations. Herbaceous tundra was the predominant habitat used by both males and females during the summer (Pitcher, 1982).

During the autumn rut, the herd concentrated in three areas: northeastern Talkeetna Mountains, Lake Louise Flats, and, to a lesser extent, the Alphabet Hills. During this period, the herd made greater use of the shrubland and spruce forest habitats (Pitcher, 1982, 1983).

In 1980-1982, the herd overwintered at lower elevations on the Lake Louise Flats and eastward (Fig. K-8). Historically, however, the main herd has overwintered in various areas throughout its range (Hemming, 1971). The Upper Susitna-Nenana subherd tended to overwinter in the Monahan Flat to Coal Creek area, although a few individuals overwintered in the Chulitna Mountains (Fig. K-8).

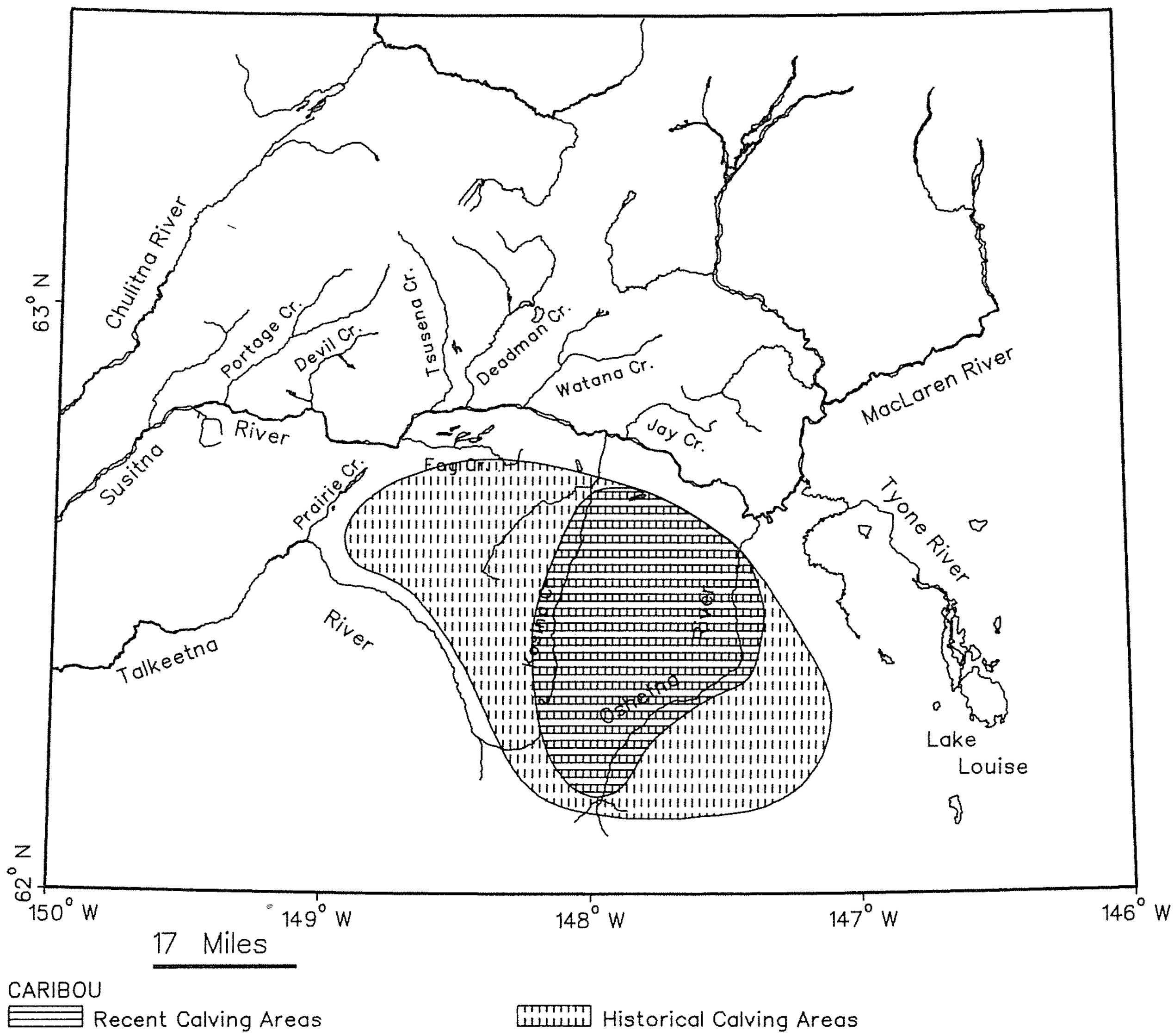

Figure K-6. General Range of Main Nelchina Caribou Herd during the Calving Period (May 15 through June 10) from 1980 through 1982 within the Upper/Middle Susitna Basin. [Source: Pitcher, 1982, 1983]

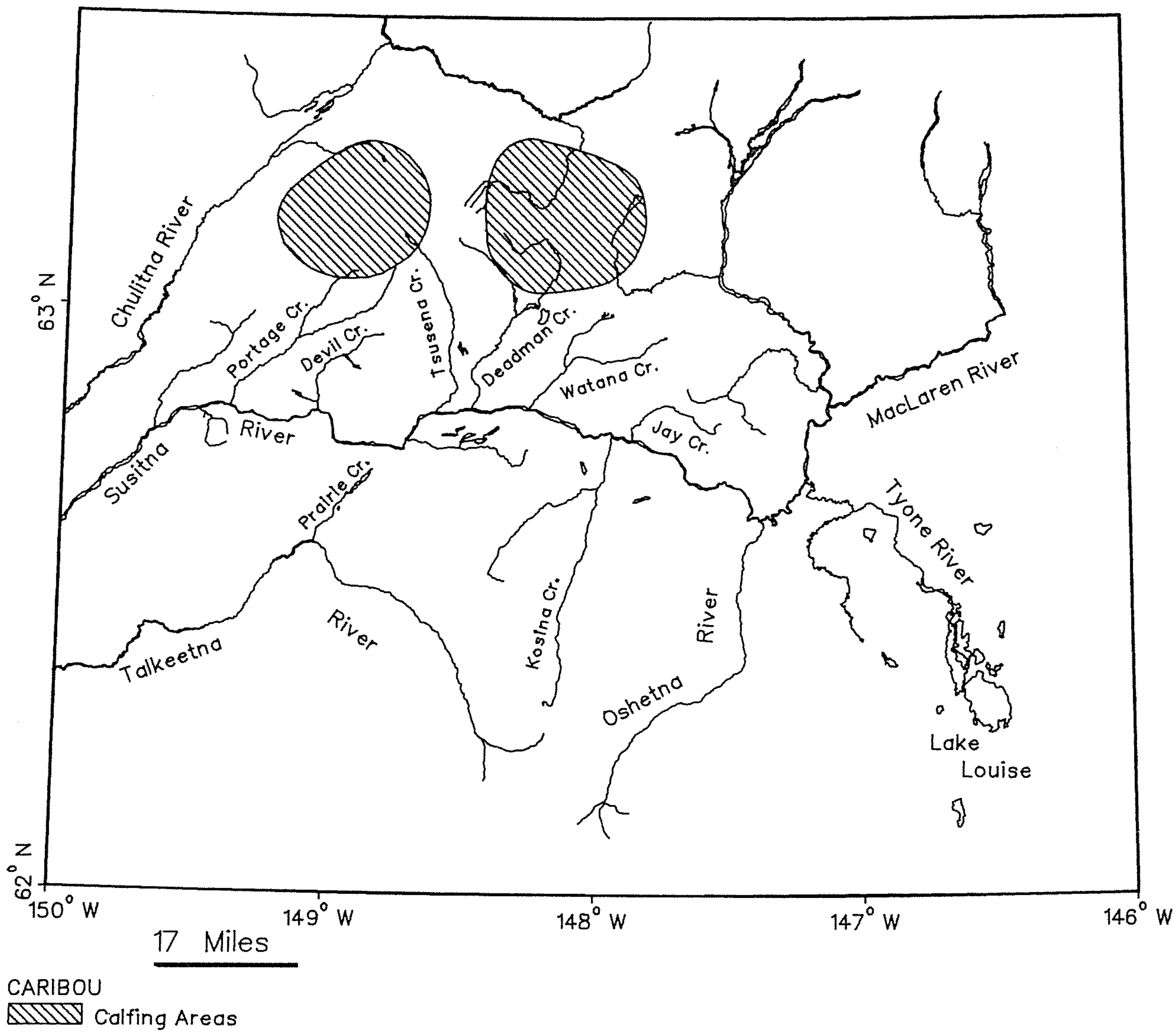

Figure K-7. General Range for Calving by the Upper Susitna-Nenana Caribou Subherd from 1980 through 1982. [Source: Pitcher, 1982, 1983]

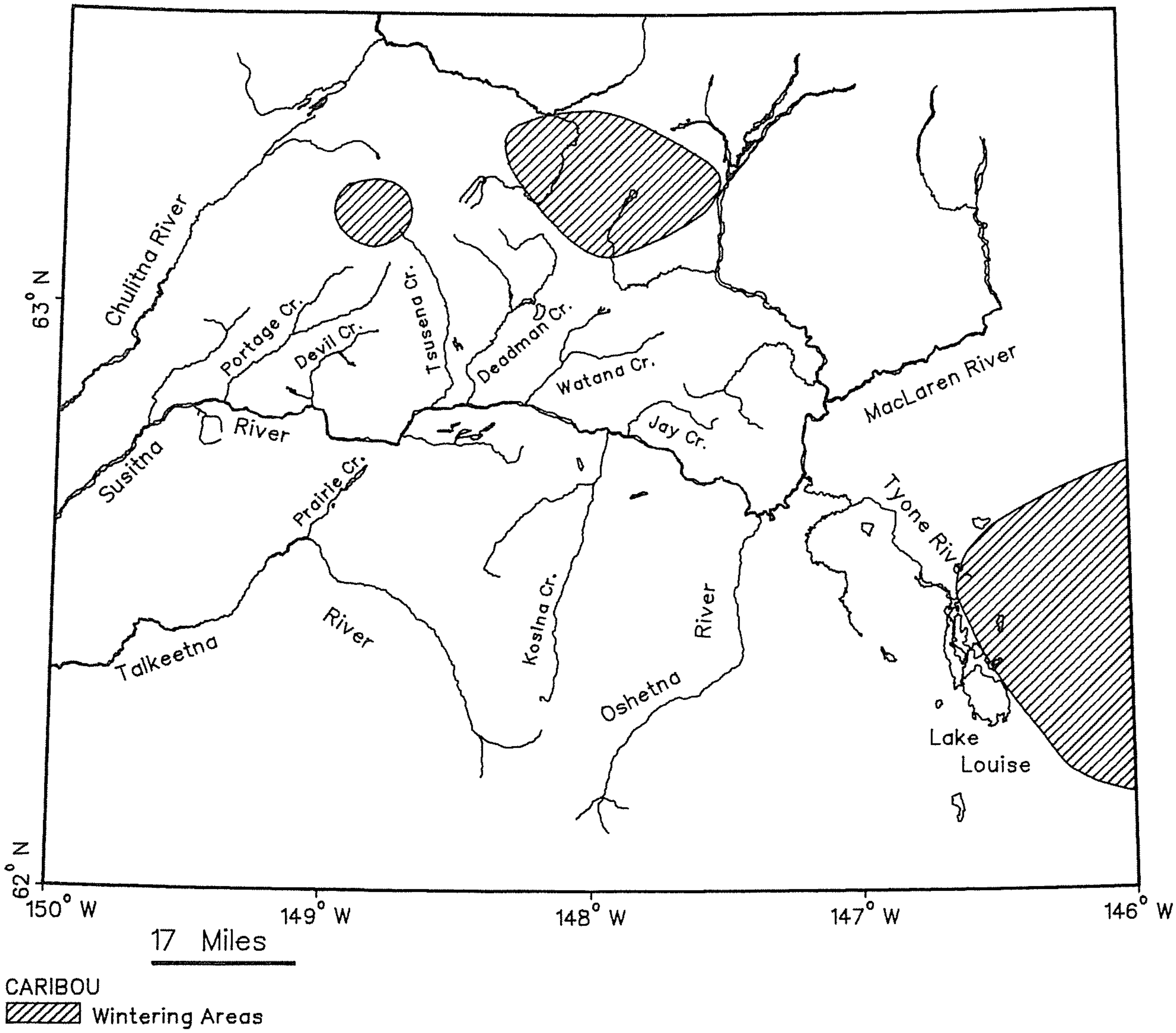

Figure K-8. General Wintering Range for Nelchina Caribou Herd from 1980 through 1982. [Source: Pitcher, 1982, 1983]

Caribou primarily occupied spruce forest habitats during the winter. In the spring, the females moved to the calving grounds and the males dispersed over a broader area (Pitcher, 1982).

MOVEMENTS

Caribou move from area to area in response to availability of forage and cover, as well as to avoid stressful weather conditions. Caribou tend to make traditional use of seasonal range for various aspects of their life history (Bergerud, 1980; Miller, 1982). Movements between traditional ranges appear to be well-structured. Some individual subherds and herds exhibit a marked affinity for specific seasonal ranges and migration routes.

Over the past several decades, the main Nelchina herd has had wintering concentrations in various areas of its range (Hemming, 1971). Recently, winter range has been south and east of the proposed impoundment areas in the area of Lake Louise and eastward (Fig. K-8), although occasional use of the area from Deadman Creek eastward has been observed (Pitcher, 1982, 1983). Thus, the major spring migration of females to the traditional calving grounds in the Talkeetna Mountains (Fig. K-8) would not generally require crossing of the Susitna River. However, it is likely that movement of males to spring and summer range would necessitate such a crossing. Pitcher (1982, 1983) suggests that as the size of the herd increases, the likelihood of crossing the proposed project areas would increase because the herd has historically tended to use a broader area at higher population sizes.

K.2.1.1.3 Dall's Sheep

Dall's sheep (Ovis dalli) are the mountain sheep characteristic of Alaska's rugged mountain areas, such as the Talkeetna Mountains and the Alaska Range (Nichols, 1980; Lawson and Johnson, 1982). Dall's sheep typically utilize alpine habitat, rarely extending below timberline. Sheep are found on steep, open terrain interspersed with rocky slopes, ridges, cliffs and rugged canyons. Sheep are chiefly grazers of grasses and forbs but will consume other vegetation if available. Typically, sheep aggregate into bands of 2 to 15 ewes and lambs or rams. Wolf are the principal predator upon Dall's sheep.

In the proposed project area, Dall's sheep are found in three areas: Portage/ Tsusena Creek drainage, south of the Susitna River from Fog Lakes to Kosina Creek, and east of Watana Creek in the Watana Hills (Fig. K-9). Surveys carried out from 1980 to 1982 found a peak number of about 70 sheep in the Mt. Watana/Grebe area and over 200 in the Watana Hills area (Ballard et al., 1982c). In general, the range of the Dall's sheep is outside the projected area of effect for the proposed project; however, an important mineral lick for the Watana Hills population is located in a portion of lower Jay Creek that might be inundated by the proposed Watana impoundment.

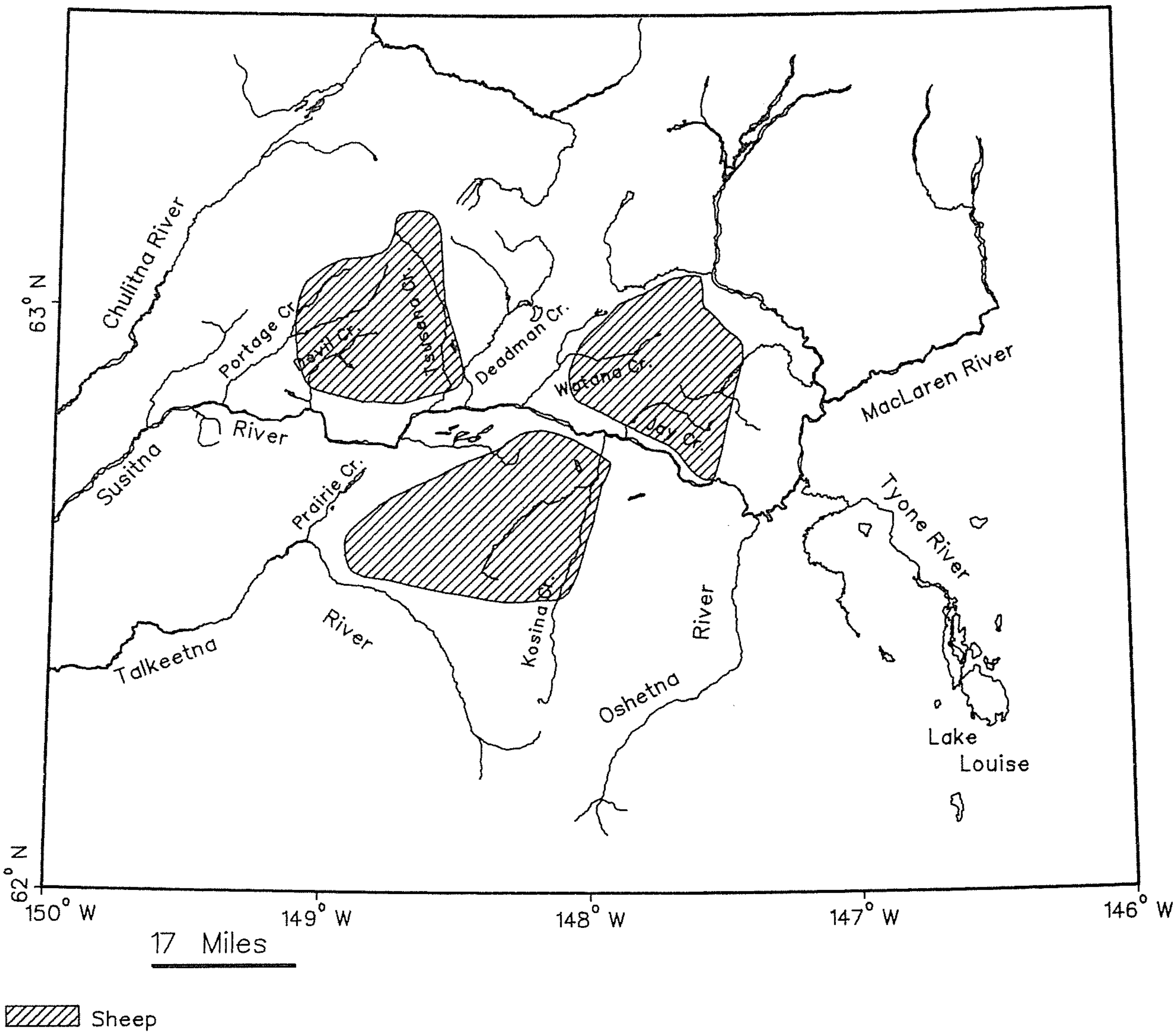

Figure K-9. Dall's Sheep Range in the Upper/Middle Susitna Basin. [Source: Ballard et al., 1982c]

Mineral licks are generally considered to be key habitat requirements for Dall's sheep (Nichols, 1980; Lawson and Johnson, 1982). The presence of mineral licks can affect the patterns of movement and distribution of sheep bands. Mineral licks are important sources of supplemental mineral nutrients for ungulates (Weeks and Kirkpatrick, 1976; Robbins, 1983). Sodium is generally thought to be the principal nutrient supplied by mineral licks (Jordan et al., 1973; Weeks and Kirkpatrick, 1976; Belovsky and Jordan, 1981; Fraser and Hristienko, 1981; Robbins, 1983; Tankersley and Gasaway, 1983). Terrestrial plant forage is generally low in sodium (Botkin et al., 1973), hence, supplemental sources are required. Use of mineral licks by ungulates is usually most intense during spring and early summer (Weeks and Kirkpatrick, 1976; Fraser and Hristienko, 1980; Tankersley and Gasaway, 1983). This appears to be related to the sodium/potassium imbalances resulting from (1) increased post-winter intake of potassium and water concomitant with increased food intake and (2) the high potassium content of the spring phenological stages of forage plants.

The Jay Creek mineral lick receives heavy use by bands of sheep and is considered important to the maintenance of the Watana Hill sheep population; Ballard et al. (1982c) and Tankersley (1983) observed up to 15 sheep (7% of the observed population for the Watana Hills) using the lick at one time. Tankersley also reported that others have observed up to 23 individuals at the lick at one time. Several other licks have been located in the Watana Hills range; however, the relative importance of these licks has not been documented. Tankersley (1983) suggested that the Jay Creek lick is of greater importance in view of its intense use, despite its location in atypical sheep habitat and its distance from the center of most sheep sightings. Other licks are in more typical habitat, closer to the majority of sightings.

K.2.1.1.4 Brown Bear

Brown bear (Ursus arctos) (also called grizzly bear) are widespread throughout Alaska (Alaska Dept. of Fish and Game, 1973, 1978; Jonkel, 1980; Craighead and Mitchell, 1982). These large carnivores are characteristically found in upland, open habitat, although they use a variety of habitats throughout the year. Individual brown bear range widely during the course of the year, exploiting a variety of food sources. Ballard et al. (1982d) reported average home ranges of about 160 and 300 mi^2 (410 and 780 km^2) for females and males, respectively. Bears appear to make traditional movements to exploit sources of high-quality food (Craighead and Mitchell, 1982). Brown bear are omnivorous, feeding upon a broad range of foods, such as salmon, ungulates (e.g., moose and caribou), carrion, and plant material (berries and foliage). Diets vary with the availability of food types and the nutritional state of individual bears. Animal food makes up 50% to 60% of the diet.

CONDITION OF THE POPULATION

Within the study area of Miller and coworkers (Miller and McAllister, 1982; Miller and Ballard, 1982), brown bear densities ranged from about 4 to 6 individuals per 100 mi^2 (1.5 to 2.5/100 km^2) in the upper and middle Susitna Basin; thus, in the 3,300-mi^2 (8,500-km^2) brown-bear study area, there were an estimated 130 to 200 brown bear in 1979. The population has a high proportion of young and is considered to be one of the most productive populations in Alaska (Exhibit E, Vol. 6A, Chap. 3, p. E-3-336), although Miller and McAllister (1982) infer from the large home ranges of individuals that the area may have low productivity of food species.

DISTRIBUTION AND HABITAT USE

Brown bear utilize an extensive variety of habitats within the basin (Miller and McAllister, 1982). In the spring (May to June) brown bear were most frequently observed in spruce habitats along the river and in upland shrublands (Table K-3). Use of the lowland areas during spring may reflect the availability of new-growth plant forage as well as a tendency for bear to concentrate in the general area of moose calving (see Fig. K-3). In spring, females with cubs were more frequently observed in upland shrub habitats (ca. 50% of the observations) and other upland areas (35%). As the summer progressed, all brown bear became more frequently observed (50%-60%) in upland shrub habitats. This may reflect a response to availability of the summer berry crop in the upland areas. During July and August, about 20% of the observations occurred in riparian habitat, probably reflecting use of these areas for salmon fishing by the bear. During fall and winter most observations (ca. 70%) occurred in upland snow and ice areas.

In the upper and middle Susitna Basin, brown bear have been documented as making directional movements to areas of seasonal food abundance (Miller and McAllister, 1982; Miller, 1983). During salmon spawning season (July-August), some brown bear moved to salmon spawning streams. Prairie Creek is the most interior of these streams and drains from Stephan Lake into the Talkeetna River. Miller and McAllister (1982) estimate that 30 to 40 bear use this stream each summer. From 1980 to 1982, 10% to 35% of the radio-collared bear in the basin moved to the Prairie Creek during July and August. The greatest distance traveled by a bear to reach Prairie Creek was about 35 mi (50 km). Based upon observed home ranges, the Prairie Creek spawning area attracts bear from an area of about 2,200 mi^2 (5,700 km^2), including areas to the north of the Susitna River.

Table K-3. Aerial Observations of Brown Bear by Season in Each of Five Habitat Categories within the Upper/Middle Susitna Basin

Habitat Type	Spring		Summer		Fall/Winter		Habitat Total
	May	June	July	August	September	October-April	
Spruce							
Number of bear	44	50	17	16	9	5	141
Percentage†[1]	(31.0)	(29.6)	(19.3)	(17.6)	(25.0)	(13.2)	
Riparian							
Number of bear	16	26	22	20	4	1	89
Percentage†[1]	(11.3)	(15.4)	(25.0)	(22.0)	(11.1)	(2.6)	
Shrubland							
Number of bear	39	75	46	52	21	5	238
Percentage†[1]	(27.5)	(44.4)	(52.3)	(57.1)	(58.3)	(13.2)	
Tundra							
Number of bear	12	14	1	1	0	0	28
Percentage†[1]	(8.5)	(8.3)	(1.1)	(1.1)	(0)	(0)	
Other†[2]							
Number of bear	31	4	2	2	2	27	68
Percentage†[1]	(21.8)	(2.4)	(2.3)	(2.2)	(5.6)	(71.1)	
Total observed	142	169	88	91	36	38	564

†[1] Percentage of total observations within an observation period.

†[2] Mostly snow and bare rock.

Source: Miller and McAllister (1982), Table 21.

Movement of brown bears to areas of moose or caribou concentrations are not well documented for the basin. Miller and McAllister (1982) do provide evidence that some individuals moved to calving areas of the Nelchina caribou herd (Fig. K-6). Movements to moose calving areas cannot be readily distinguished from movements to spruce habitat in order to exploit new-growth plant forage.

DENNING

Brown bear overwinter in an inactive state of winter sleep or hibernation (Craighead and Mitchell, 1982). During this inactive period, body temperature and metabolic activity are reduced. Although individuals may awaken during this period, they generally do not feed, relying instead on body stores of fat to meet their energy needs. Therefore, in the early spring, emerging bear are in a state of negative nutritional balance.

Brown bear overwinter within dens excavated into slopes of relatively loose soils (Craighead and Mitchell, 1982). Dens serve to minimize thermoregulatory demands during winter inactivity. Most dens of brown bear are newly excavated each year, although some dens may be reused. During studies in the upper and middle Susitna Basin, brown bear dens were typically located on south-facing slopes at an average elevation of about 4,000 ft (1,200 m) MSL (Miller, 1983). Of 31 dens found in the area, only three occurred at elevations below 2,500 ft (760 m). Habitats around dens were typically upland tundra and shrubland. None of the dens observed were reused during the study period of 1980-1982. Bears typically entered dens in October and emerged in late April-early May, a period of about six months (Miller, 1983). Adult males generally enter dens later and emerge earlier than other age and gender classes.

K.2.1.1.5 Black Bear

Black bear (Ursus americanus) are the most common North American bear; in Alaska they range northward to the Brooks Range (Alaska Dept. of Fish and Game, 1973, 1978; Pelton, 1982). Spruce forest is a principal component of black bear habitat in Southcentral Alaska. Black bear range widely in response to varying availability of food. Although black bear are omnivorous, animal matter makes up a smaller proportion (5%-20%) of the diet than is the case for brown bear (50%-60%). Diets vary with food availability and include fresh plant growth in spring, summer berries, and carrion. Home ranges of males are generally larger [2-80 mi^2 (5-200 km^2)] than those of females [1-20 mi^2 (2-50 km^2)] (Pelton, 1982).

Miller (1983) surveyed for black bear in a 1,600-mi^2 (4,200-km^2) study area within the upper and middle Susitna Basin. Based upon that survey, the Applicant estimated that in the range of 50 to 170 black bear were present in the study area, although more may have been present (Exhibit E, Vol. 6A, Chap. 3, p. E-3-342). In the upper and middle Susitna Basin, the population appears to be productive and healthy even though the extent of suitable habitat is limited to about 550 mi^2 (1,400 km^2) (Miller and McAllister, 1982; Miller, 1983). Black bear tended to only use habitat adjacent to the mainstem of the Susitna River (Fig. K-10). In the spring, spruce habitat received the most use (ca. 50% of observation) by black bear (Table K-4). Throughout the year, black bear observations in spruce habitat exceeded 30% of total observations. That black bear were restricted to lowland habitat is evidenced by the fact that only 1% of the relocations occurred at elevations above 3,500 ft (1,100 m) MSL (Miller, 1983). The restricted habitat use of black bear was probably a function of availability of suitable cover and forage, availability of suitable denning areas, and competition from brown bear located chiefly in the uplands.

As expected, some black bear made seasonal movements, apparently in response to varying food availability (Miller and McAllister, 1982). In summer, a number of individuals moved into the shrub-dominated tablelands along the Susitna River, principally to the north. During the summer months, black bear were often observed (45% to 55% of observations) in shrubland habitat adjacent to spruce habitat. These moves were apparently motivated by the availability of the ripening berry crop. Many moves necessitated crossing the river within the proposed impoundment zone.

Black bear returned to the spruce habitat for winter. The bear overwintered in dens along the Susitna River, entering mid-September to mid-October and emerging from early April to mid-May (Miller and McAllister, 1982; Miller, 1983). Dens were typically located in steep terrain on south-facing slopes within forested habitat. Of 54 dens located, only two were found at elevations above 3,100 ft (940 m) MSL; average elevation was about 2,000 ft (600 m) MSL. About 50% of the dens were natural cavities, and about 50% of the dens had been previously used (Miller, 1983).

K.2.1.1.6 Gray Wolf

Gray wolf (Canis lupus) range throughout a variety of habitats in Southcentral Alaska, from tundra to forest. The principal habitat feature determining the presence of wolf appears to be the availability of suitable prey (Paradiso and Nowak, 1982). Wolf are almost exclusively

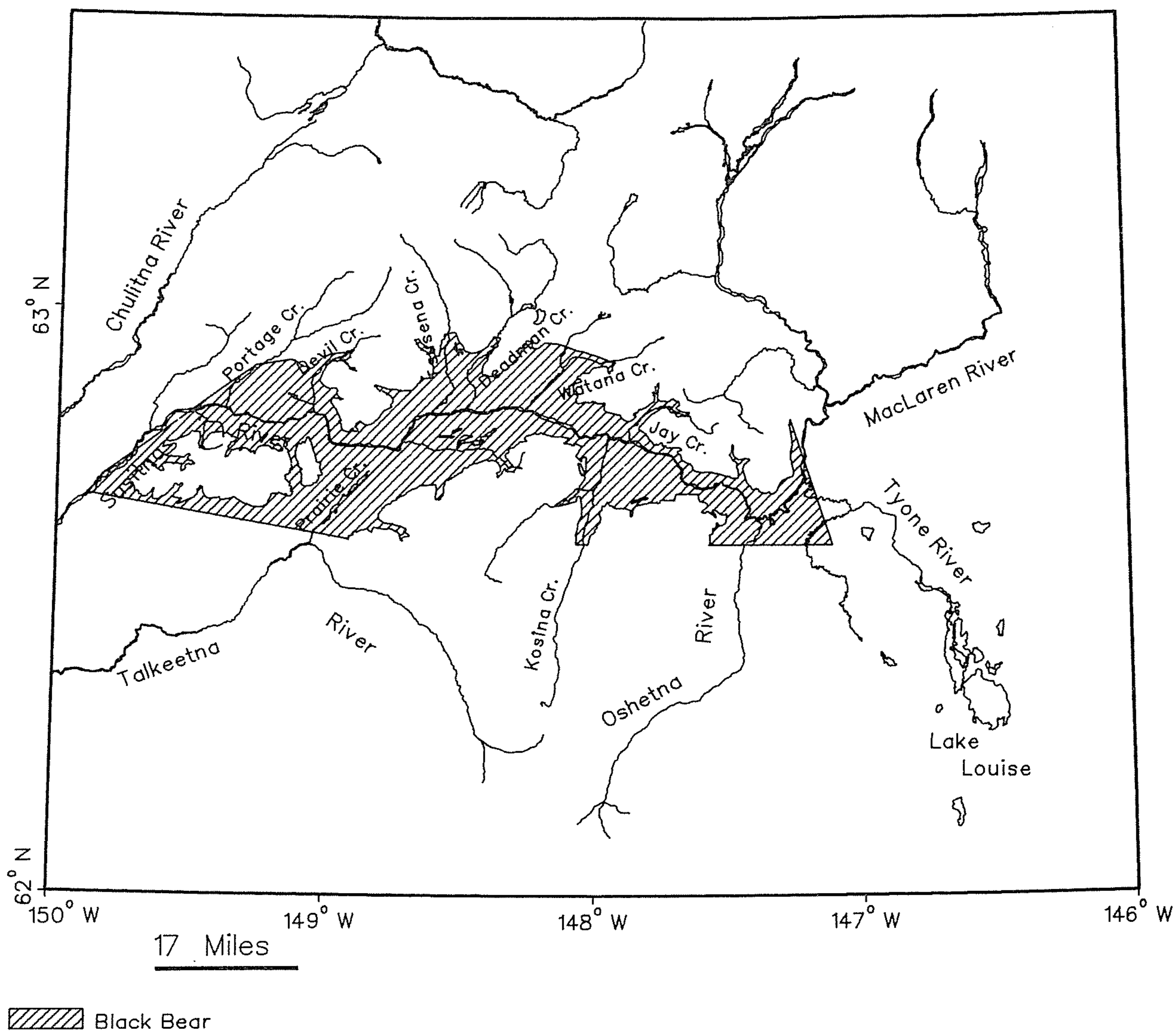

Figure K-10. General Range of Black Bear in the Upper/Middle Susitna Basin. [Source: Miller and McAllister, 1982; Miller, 1983]

Table K-4. Aerial Observations of Black Bear by Season in Each of Five Habitat Categories in the Upper/Middle Susitna Basin

Habitat Type	Spring		Summer		Fall-Winter		Habitat Total
	May	June	July	August	September	October-April	
Spruce							
Number of bear	82	95	54	68	44	15	358
Percentage†[1]	(50.3)	(46.3)	(35.8)	(31.8)	(30.8)	(46.9)	
Riparian							
Number of bear	23	33	23	18	23	1	121
Percentage†[1]	(14.1)	(16.1)	(15.2)	(8.4)	(16.1)	(3.1)	
Shrubland							
Number of bear	50	70	69	119	71	9	388
Percentage†[1]	(30.7)	(34.1)	(45.7)	(55.6)	(49.7)	(28.1)	
Tundra							
Number of bear	3	3	3	6	2	0	17
Percentage†[1]	(1.8)	(1.5)	(2.0)	(2.8)	(1.4)	(0)	
Other†[2]							
Number of bear	5	4	2	3	3	7	24
Percentage†[1]	(3.1)	(2.0)	(1.3)	(1.4)	(2.1)	(21.9)	
Total observed	163	205	151	214	143	32	908

†[1] Percentage of observation in each observation period.

†[2] Mostly snow and bare rock.

Source: Miller and McAllister (1982), Table 44.

carnivorous, and their diet generally consists of large prey such as moose, caribou, and Dall's sheep. Wolf predation appears to be a major factor in limiting the sizes of Alaskan ungulate populations (Bishop and Rausch, 1974; Ballard et al., 1981b; Gasaway et al., 1983). In the basin, wolf apparently play a minor role in limiting moose numbers, but do constitute the principal limiting factor for caribou (Ballard et al., 1981a,b; Pitcher, 1982, 1983).

Wolf generally occur in groups, or packs, of several individuals. During recent studies, 13 known or suspected wolf packs ranged through the upper and middle Susitna Basin (Fig. K-11). In the basin, pack sizes varied from 2 to 15 individuals (Ballard et al., 1981b, 1982e, 1983b). The total number of wolf in the basin ranged from 20 to 50 from 1980 to 1982. In general, wolf packs tend to maintain exclusive, non-overlapping ranges or territories (Paradiso and Nowak, 1982). Territory sizes in the project area ranged from 360 to 980 mi^2 (930 to 2,500 km^2) (Ballard et al., 1982e).

Wolf movement during the summer generally centers around the den and rendezvous site (Paradiso and Nowak, 1982). In the project area, wolf moved seasonally into different areas of their range. Lower elevations were generally used more frequently in winter than in summer (Ballard et al., 1983b). Wolf movements appeared to be affected by distribution of suitable prey, chiefly moose and caribou.

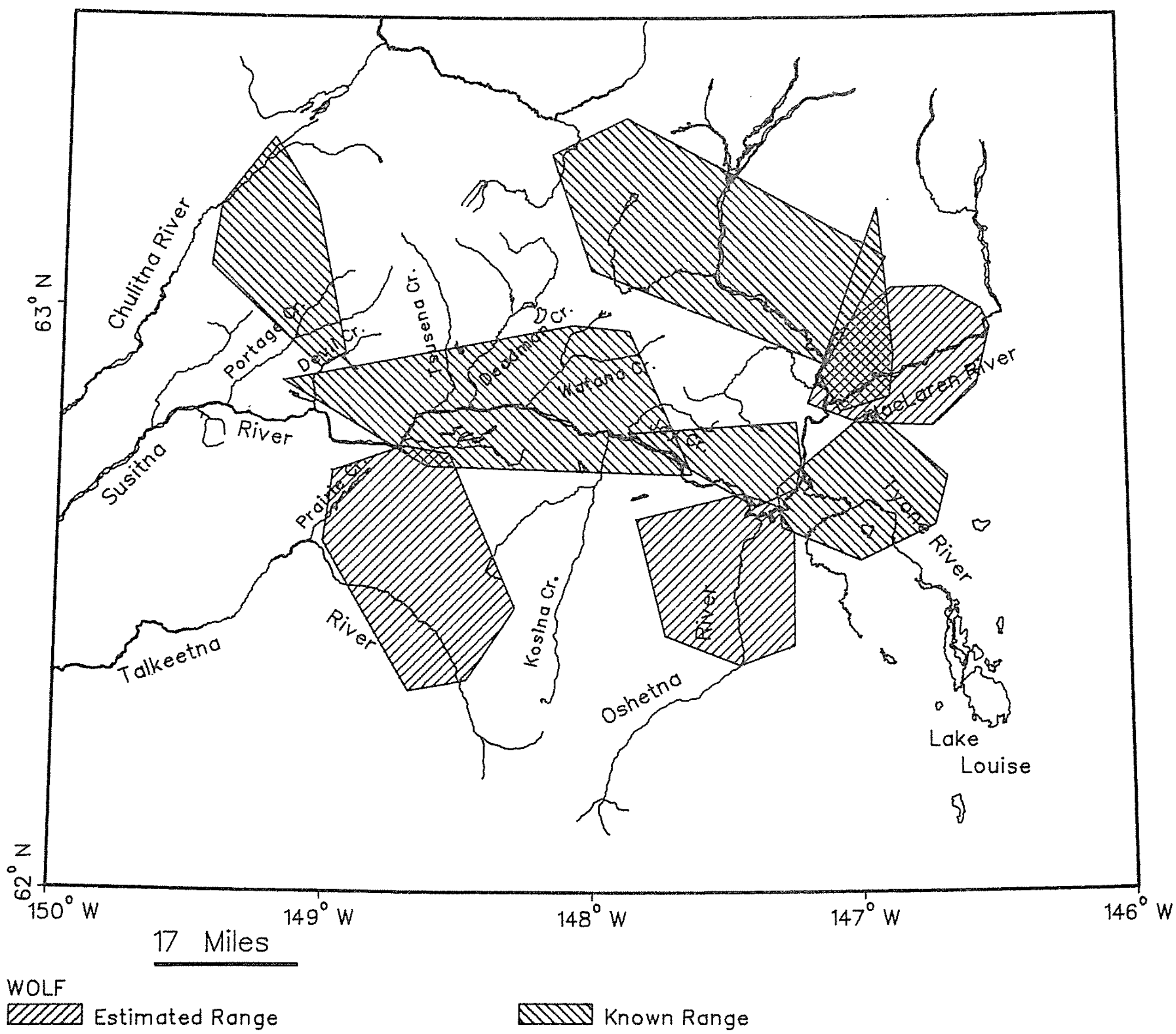

Figure K-11. Known and Suspected Territorial Boundaries of Wolf Packs Inhabiting the Upper/Middle Susitna Basin. [Source: Ballard et al., 1983b: Fig. 1]

K.2.1.1.7 Beaver

Beaver (Castor canadensis) are semiaquatic furbearers ranging along most of the streams of Southcentral Alaska (Hill, 1982). Beaver typically prefer small streams or slow-flowing waters or lakes and impoundments with stable water levels. Fast-flowing waters or fluctuating water levels are generally unsuitable (Slough and Sadleir, 1977; Allen, 1982a). Beaver require a minimum of 1.5 ft (0.5 m) of ice-free water to successfully overwinter in lodges or dens (Slough and Sadleir, 1977).

Beaver are uncommon along much of the Susitna River and its major tributaries (Gipson et al., 1982). Aerial surveys identified the majority of beaver sign in lakes on the benches above the river valley at elevations of 2,000 to 2,400 ft (610 to 730 m). Beaver populations also were observed along the slower-flowing sections of most major creeks. Gipson et al. (1982) observed no active lodges or dens on the river itself or on the lower reaches of tributary streams. In a 1982 survey, densities of about one active beaver lodge per mile (0.5/km) were found along the middle stretches of Deadman Creek (Exhibit E, Vol. 6A, Chap. 3, p. E-3-357); higher densities occurred in the upper, marshy reaches of the creek. An estimated 65 beaver occupied this creek.

K.2.1.1.8 Pine Marten

Pine marten (Martes americana) are typically found in spruce and mixed forest habitat in Alaska (Strickland et al., 1982; Allen, 1982b). Thus, in the project area this furbearer is restricted to habitat adjacent to the mainstem Susitna River. Foods include small mammals, passerine birds, invertebrates, and berries.

Surveys in 1980 indicated that marten occurred at least from Portage Creek to the Tyone River (Gipson et al., 1982). They were considered locally abundant in the areas of the two proposed impoundments. Densities were estimated as about 2/mi^2 (0.8/km^2) from Deadman to Watana creeks. Track counts in 1980 identified most numerous marten sign in spruce forest below 3,300 ft (1,000 m) (Gipson et al., 1982).

K.2.1.1.9 Other Furbearers

A number of other furbearers occur within the upper and middle Susitna Basin. Wolverine (Gulo gulo) occur throughout the area. An estimated 120 wolverine occupied the basin in 1980 (Gardner and Ballard, 1982). Muskrat (Ondatra zibethicus) occur throughout the Susitna drainage up to about 3,300 ft (1,000 m) MSL. Most muskrat sign was observed in lakes above the river valley [900 to 2,800 ft (260 to 860 m) MSL] and along the slower stretches of larger creeks (Gipson et al., 1982). River otter (Enhydra lutra) and mink (Mustela vison) were common along the river and major tributaries up to 4,000 ft (1,200 m). Mink were most abundant in the upper reaches of the proposed Watana impoundment site.

Red fox (Vulpes vulpes) have been observed throughout the project area. Gipson et al. (1982) most frequently observed fox at high elevations near or above the timberline. The authors estimated a density 4-6 fox/32 mi^2 (83 km^2) and concluded that densities were low relative to other areas in Alaska.

Other furbearers in the project area include lynx (Felis lynx), coyote (Canis latrans), and weasels (Mustela erminea, M. nivalis).

K.2.1.1.10 Other Mammals

Small non-game mammals occur throughout the area (Kessel et al., 1982). Shrews (Sorex spp., Microsorex hoyi) and red-backed voles (Clethrionomys rutilus) were observed in all habitat types. In contrast, other voles (Microtus spp.) displayed a strong preference for open, unforested habitat. Lemmings (Lemmus sibericus, Snyaptomys borealis) were uncommon in the area. Arctic ground squirrels (Spermophilus parryii) were prevalent in herbaceous tundra and shrubland above the timberline. Hoary marmots (Marmota caligata) and pika (Ochotona collaris) were generally restricted to tundra/talus habitat at higher elevations. The arboreal red squirrel (Tamiasciurus hudsonicus) was found in coniferous forest habitat. Snowshoe hare (Lepus americanus) were relatively sparse in the area, presumably because of the paucity of suitable habitat, i.e., recent burns and riparian shrub thickets.

K.2.1.1.11 Golden Eagle

Golden eagle (Aquila chrysaetos) nest in cliff habitat throughout the state. A large portion of the suitable nesting locations for golden eagle in Southcentral Alaska occurs along the middle Susitna River in the area of the proposed project (Exhibit E, Vol. 6A, Chap. 3, p. E-3-444). The number of observed active nests in the upper and middle Susitna Basin suggests that the area supports one of the highest populations in the state (Kessel et al., 1982). Of 16 known nesting locations in the project area, 7 or 8 were in the projected Devil Canyon and Watana impoundment areas (Exhibit E, Vol. 6B, Chap. 3, Table E.3.160). Golden eagles tend to hunt in open treeless areas or along the forest edge (Bent, 1961; Armstrong, 1981). Principal foods are small mammals and birds.

K.2.1.1.12 Bald Eagle

The bald eagle (Leucocephalus haliaeetus) is an uncommon breeder in the basin; the majority of bald eagles nest along coastal Alaska, south of the upper and middle Susitna Basin. Suitable nesting locations for bald eagle are limited upstream from Devil Canyon, and the principal concentrations of these raptors are situated downstream. Six nesting locations are situated in the project area (Exhibit E, Vol. 6B, Chap. 3, Table E.3.160). Nests occur in the tops of tall trees and rarely in riverine cliffs. Bald eagles hunt over open waters of the Susitna and major tributaries. Fish and waterbirds are likely principal prey of this species in the project area. During salmon spawning, Prairie Creek may be a source of prey.

K.2.1.1.13 Other Raptors and Raven

Gyrfalcons (Falco rusticolus) are uncommon in Southcentral Alaska but do regularly nest in the Alaska Range, to the north of the project area (Kessel et al., 1982). Three gyrfalcon nest locations have been observed in the project area. Three goshawk (Accipiter gentilis) nest locations have been observed in the project area, and 21 raven (Corvus corax) nest locations have also been observed during 1980-1981 surveys. Some suitable nesting habitat for other raptors does occur along the Susitna River (Exhibit E, Vol. 6A, Chap. 3, p. E-3-276).

K.2.1.1.14 Trumpeter Swan

Trumpeter swan (Olor buccinator) commonly breed in lacustrine habitat in the upper and middle Susitna Basin, principally east of the Susitna River, between the Oshetna and McLaren Rivers (Kessel et al., 1982). This area supports the western edge of the Gulkana Basin population, which is increasing in size. In Alaska, breeding habitat for trumpeter swans generally consists of waterbodies with stable water levels and with dense stands of emergent vegetation (Hansen et al., 1971). Although suitable breeding habitat occurs within the upper and middle basin, no breeding swans were observed in the vicinity of the proposed project features.

K.2.1.1.15 Other Waterbirds

The basin does not support large concentrations of waterbirds either during migration or breeding, although use of discrete waterbodies varied considerably (Kessel et al., 1982). Surveys in 1980-1981 indicated that the basin does not appear to be a major migration route for waterbirds. The lakes in the project area receive low use compared to areas in Interior Alaska (Figs. K-12 and K-13).

To identify the waterbodies of most value to waterbirds (loons, grebes, and waterfowl), Kessel et al. (1982) derived a relative "Importance Value" for each season for each waterbody surveyed (Figs. K-12 and K-13). The importance value of each waterbody at a given season was the sum of relative mean abundance (number of birds) from the censuses, the relative mean density (birds/km^2), and the relative mean species richness (number of species):

$$\text{IMPORTANCE VALUE of a water body} = \frac{\text{mean number of birds on waterbody}}{\text{sum of mean number of birds on all waterbodies}} + \frac{\text{mean density of birds on waterbody}}{\text{sum of mean densities of birds on all waterbodies}} + \frac{\text{mean number of species on waterbody}}{\text{sum of number of species on all waterbodies}}$$

This derived value is analogous to importance values used by plant ecologists in evaluating importance of a species within a plant association by combining measures of abundance (Greig-Smith, 1983).

K.2.1.1.16 Other Birds

More than 130 species of birds were identified in the basin in 1980-1982 (Kessel et al., 1982). Forest and woodland habitats generally supported higher densities of birds than did shrub habitats. Coniferous forests supported fewer birds than did other forest types. Alpine tundra supported the lowest number of birds, although this type supported species generally not found elsewhere.

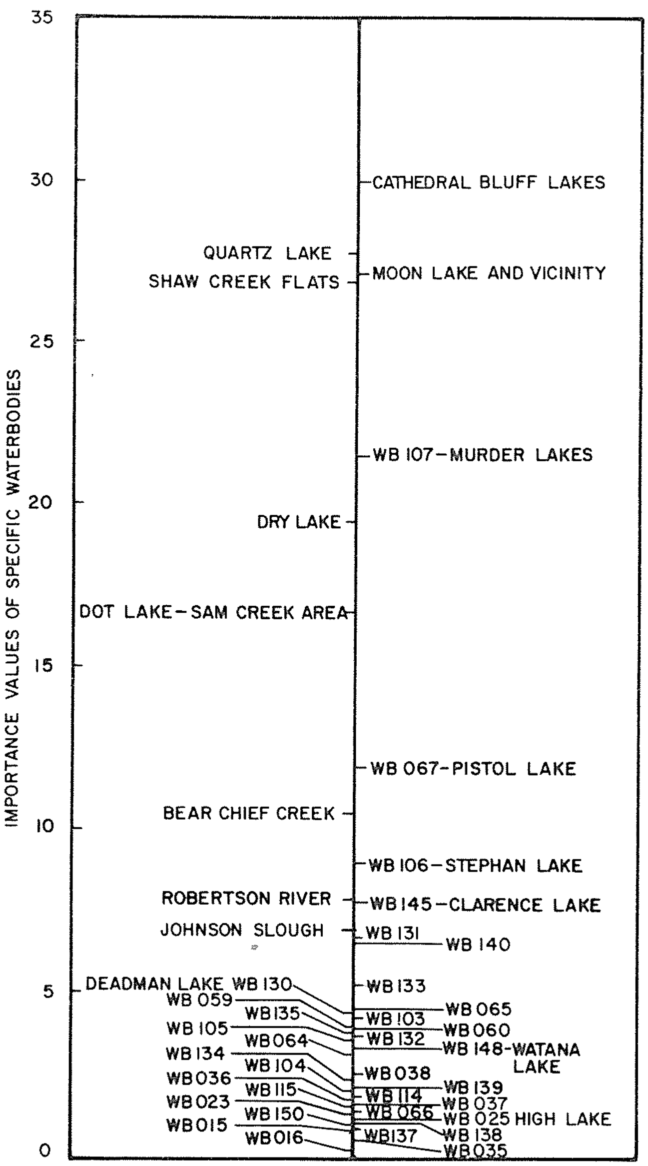

Figure K-12. Importance Values of Water Bodies for Migrant Waterfowl in the Upper/ Middle Susitna Basin (WB) and Upper Tanana River Valley--Spring 1980. [Source: Exhibit E, Vol. 6B, Chap. 3, Fig. E.3.106]

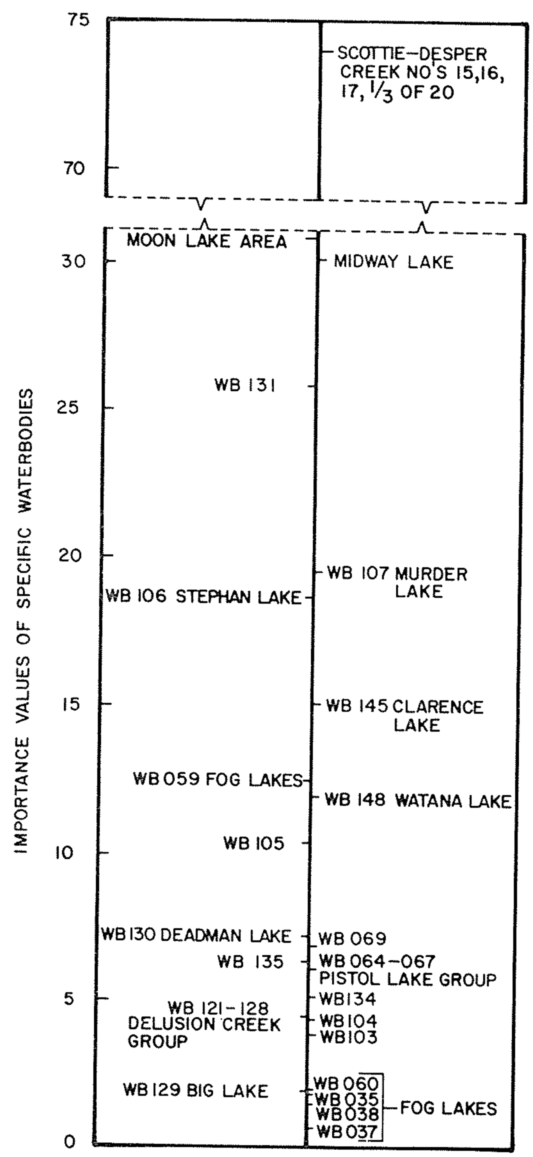

Figure K-13. Importance Values of Water Bodies for Migrant Waterfowl in the Upper/ Middle Susitna Basin (WB), and Upper Tanana River Valley and Scottie Creek Area - Fall 1980. [Source: Exhibit E, Vol. 6B, Chap. 3, Fig. E.3.107]

K.2.1.1.17 Human Use and Management of Wildlife

A principal human use of the upper and middle Susitna Basin is the harvesting of big game and furbearers (see Appendices F and L). Wildlife harvesting is carried out for recreational, subsistence, and commercial purposes. Wildlife directly and indirectly contribute to the economy of this sparsely settled basin and adjacent areas (see Appendix N). A secondary human use is non-consumptive viewing of wildlife, chiefly big game and birds. This recreational use is generally restricted to the periphery of the affected project area.

The responsibility for regulating human uses of wildlife and managing wildlife resources of Alaska rests in the Alaska Department of Fish and Game, which implements the management policies of the Alaska Board of Game. The region surrounding the project is administratively divided into Game Management Units (GMU) (Fig. K-14), and most data on human use of wildlife resources are collected on the basis of management units. The principal project features are situated in GMU 13.

Access to the core of the project area is limited by the number and quality of ground transportation routes (see Appendix N). The principal modes of transport are air; off-road, all-terrain vehicles; and a combination of highway and foot access (Exhibit E, Vol. 7, Chap. 5, p. E-5-111). In addition, boat access is available from Talkeetna to Devil Canyon and from Denali Highway to Vee Canyon. Limited access to the area serves, in part, as a constraining factor on the human use of the basin's wildlife resources.

The principal human use of big-game animals is for sport hunting. There is no direct commercial exploitation of game populations (Exhibit E, Vol. 7, Chap. 5, p. E-5-102), but commercial trapping and some hunting of furbearers to obtain pelts does occur.

Subsistence uses of wildlife resources have a recognized priority under both Federal and state laws, provided that such uses do not interfere with wildlife conservation goals. Subsistence users harvest game and furbearers principally as a source of food, clothing, or other utilitarian purposes. These user goals encompass both the objective of obtaining quality goods at relatively low cost and fulfilling of cultural traditions and obligations. Thus, subsistence uses have both economic and sociocultural significance (see Appendix N). Subsistence user statistics are not distinguishable in harvest statistics for game species, with the exception of caribou. Therefore, specific subsistence user patterns for the area are not currently known and are incorporated into the general use patterns discussed below.

Indirect commercial benefits accrue from recreational and subsistence hunting of game species. Big game hunting by non-residents of Alaska requires by law the employment of licensed guides. In addition to offering guiding services, these guides may provide transportation, lodging, food, or camping services. There are a number of lodges in the general region of the proposed project that serve consumptive and non-consumptive users of game resources in the impact area. In addition, financial gain can accrue to interests outside the project region through supplying users with transportation, food, equipment, taxidermy services, and meat and hide preparation.

The principal game species in the area that would be affected by the project are moose, caribou, Dall's sheep, black and brown bear, wolf, and wolverine. The status of these populations has been discussed individually above. The economic importance of each species is difficult to ascertain. There is no information on the business volume associated with each species. Moreover, hunts are often conducted as combined hunts and costs are not apportioned to each species. In lieu of such data, relative importance can be expressed on the basis of take in GMU 13 as a proportion of statewide take during 1978-1979 (Exhibit E, Vol. 7, Chap. 5, p. E-5-110): moose--14.5%; wolf--9.0%; black bear--5.0%; caribou--9.0%; brown bear--8.0%.

Moose are taken by nonresidents principally for antler trophies, whereas residents take moose for meat and recreational activity. Most resident hunters in GMU 13, 14, and 16 are from the Anchorage-Palmer and Fairbanks areas. Intensity of hunting and hunting success has varied considerably from 1970 (Fig. K-15). Hunting intensity is controlled by Alaska Department of Fish and Game regulations through three basic methods: (1) limiting the hunting season, (2) establishing harvest quotas, and (3) imposing direct limitations on effort, e.g., issuing a limited number of permits (Alaska Dept. of Fish and Game, 1983). These methods have been used to varying degrees in controlling harvest of moose and other game in the affected game management units.

Success rate (take per hunter) in GMU 13 has varied over the last 12 years from 0.19 to 0.36 (mean = 0.27) (Fig. K-15). In the late 1960s, success rates ranged from 0.3 to 0.5 (Exhibit E, Vol. 7, Chap. 5, p. E-5-117). Varying success rates are functions of varying moose population size and varying regulations over the years. The variability of success rates over time makes it impossible to generalize about the overall quality of hunting experience in the affected management units.

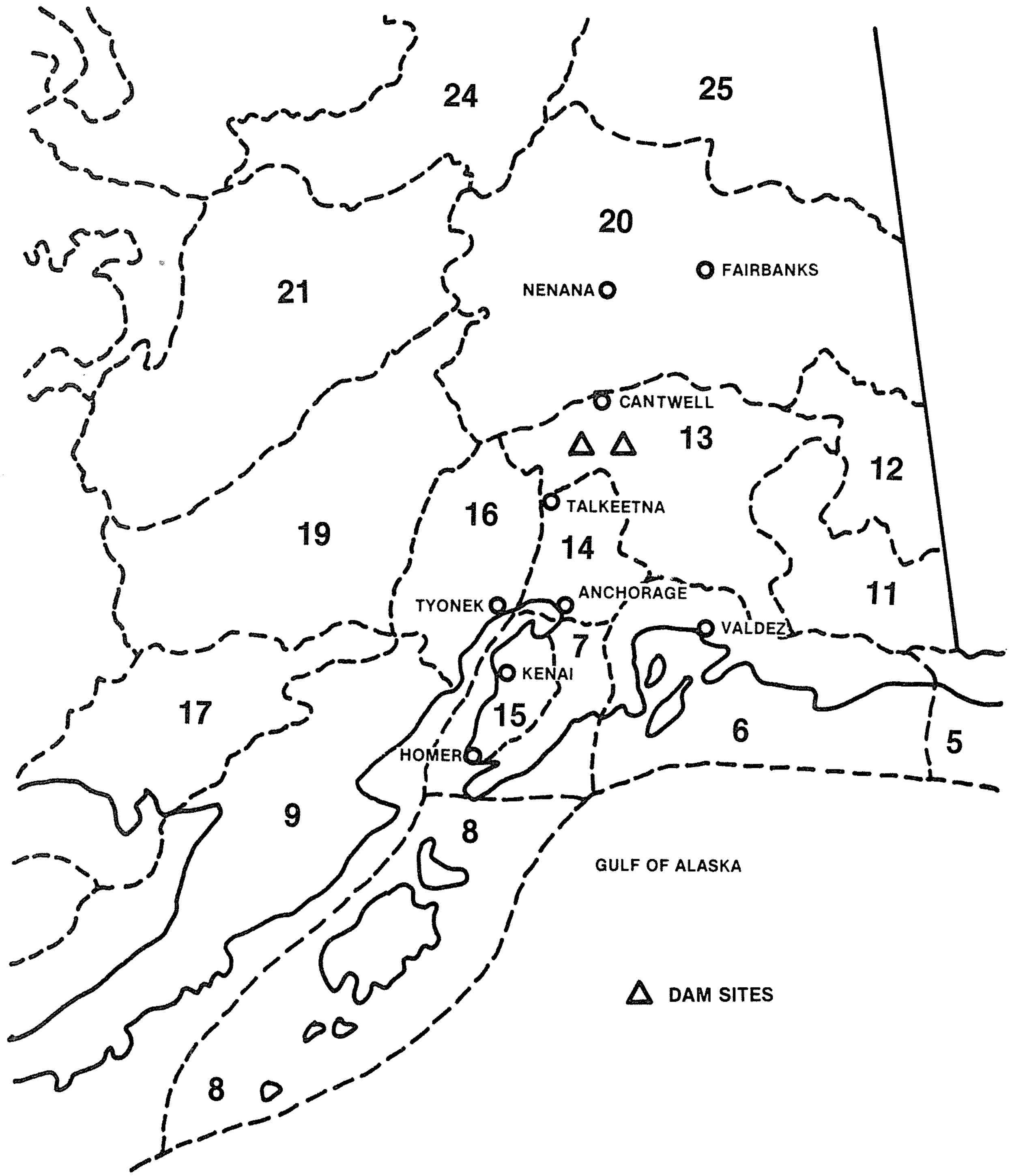

Figure K-14. Game Management Units (GMU) of Southcentral Alaska. [Source: Alaska Dept. of Fish and Game, 1981]

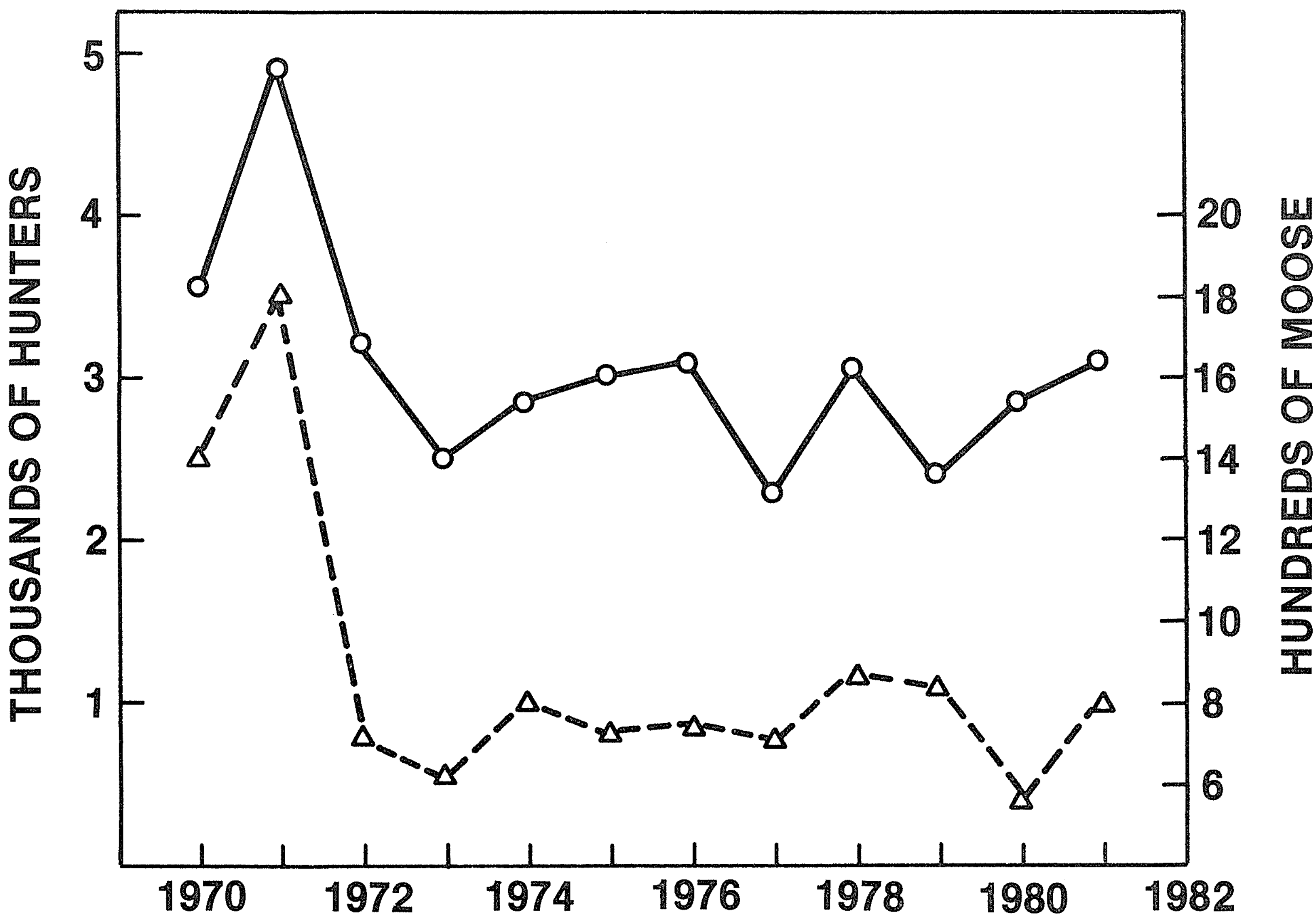

Figure K-15. Moose Hunting Intensity and Take for GMU13. (Solid line indicates number of hunters, dashed line indicates number of moose.) [Source: Exhibit E, Vol. 7, Chap. 5, Table E.5.51]

Caribou hunting provides both meat and recreational experience to regional hunters. The Nelchina caribou herd is centrally located to the major population centers of Alaska. Therefore, users of this resource are drawn principally from the Anchorage and Fairbanks areas. Current hunter participation in harvesting Nelchina caribou is less than 30% of that occurring in the early 1970s (Exhibit E, Vol. 7, Chap. 5, p. E-5-112). This reduction in hunting intensity has resulted from placing limits on the number of permits available to hunters, as well as from the establishment of a bag limit of one animal per year. These limitations are designed to maintain the herd size at about 20,000 individuals, well below historic population levels (Pitcher, 1982, 1983).

The number of caribou hunting permits available in GMU 13 and 14 is far less than the demand. In 1980, for example, more than 6,800 hunters applied for 1,300 permits, a ratio of 5:1 (Exhibit E, Vol. 7, Chap. 5, p. E-5-113). Control of the hunting intensity has led to a maintenance of a steady success rate for permitted hunters. Since 1977, success rates have climbed and stabilized at around 0.50 to 0.60. In part, the improved success rates have been correlated with a recovery in the herd size.

Dall's sheep in the project area are taken principally for head trophies rather than meat. Hunters using the Talkeetna Mountains and Chulitna/Watana Hills area are apportioned approximately 80% Alaskan residents and 20% nonresidents (Exhibit E, September 1983 Suppl., p. 5-22-8). Resident hunters are probably drawn from the principal population centers, Anchorage and Fairbanks. About 80 sheep per year are taken from the Talkeetna Mountains and Chulitna/ Watana Hills area (Ballard et al., 1982d). Hunters are allowed one ram with 7/8 curl horn or larger per year. During the period of 1971-1981, resident hunters had success rates of 0.16 to 0.33; whereas guided, nonresident hunters had success rates of 0.5 to 0.8.

Black bear are most frequently taken on incidental encounters during moose or caribou hunts (Exhibit E, September 1983 Suppl., p. 5-22-2). Few hunters value black bear sufficiently to hunt away from available transport routes in order to obtain animals. Bear hide and meat are used by hunters. Resident bear hunters are principally from the Anchorage and Fairbanks areas.

From 1973 to 1980, the take in GMU 13 averaged 66 black bears per year, with a bag limit of three bear per hunter. It is estimated that the current harvest is well below the sustainable yield for the Susitna black bear population. Data on success rates for black bear hunting are unavailable.

Brown bear are usually hunted for recreational value and trophy value of the animals' hides (Exhibit E, September 1983 Suppl., p. 5-22-4). The young age of bear taken in the Susitna Basin area suggests that hunters are not selecting large trophy individuals. In many instances, brown bear are taken incidental to moose or caribou hunts. From 1973 to 1980, an average of 64 brown bear per year were taken in GMU 13. Because it was believed that a harvestable surplus of brown bear existed in GMU 13 and that brown bear were significant predators on moose, in 1980 the Alaska Department of Fish and Game established more liberal hunting regulations for brown bear in GMU 13 (Miller and Ballard, 1980; Ballard et al., 1981a). As a result, the harvest of bear in 1980 and 1981 increased about 20% over the previous two years. The available data do not, however, allow a determination of hunter success rate during these periods.

Wolf are hunted both for recreation and for sale of pelts. Most hunters are residents of the Anchorage and Fairbanks areas (Exhibit E, September 1983 Suppl., p. 5-22-6). Currently, the only restrictions on taking wolf are limited hunting and trapping seasons. It is believed that considerable poaching occurs in GMU 13. From 1971-1977 annual take of wolves averaged about 100-120 animals and peaked at 130 in 1978-1979. Since then, the take has steadily declined. No analysis of success rate is available.

The major furbearers commercially harvested in the project area are beaver, muskrat, pine marten, mink, red fox, river otter, and weasel. Wolves and wolverine may also be trapped or hunted for fur in addition to being harvested as game species. The most intense harvesting occurs on populations of muskrat, fox, and marten (Table K-5). It appears that in general the project area is not trapped by large numbers of individuals. Only 11 individuals were reported to be trapping in the general impact area during 1980-1981 (Exhibit E, Vol. 7, Chap. 5, p. E-5-120). Trapping currently occurs principally in the areas around Stephan Lake, Tsusena Creek, Clarence Lake, and the eastern portions of the Susitna Valley.

K.2.1.1.18 <u>Threatened and Endangered Species</u>

The U.S. Fish and Wildlife Service (1983b) and Alaska Department of Fish and Game (1982) list only four taxa of wildlife as threatened or endangered in the state of Alaska. Of these, only the American peregrine falcon (<u>Falco peregrinus anatum</u>) ranges over the area of the proposed project and transmission facilities (Kessel et al., 1982; U.S. Fish and Wildlife Service, 1983c). The American peregrine falcon is listed by both Federal and state wildlife authorities as endangered. Peregrine nest in cliff ledges associated with waterbird habitat, and their principal foods are other birds, especially waterbirds (Bent, 1961; Armstrong, 1981; U.S. Fish and Wildlife Service, 1982, 1983d).

Table K-5. Trapper Exports and Dealer Purchases of Furbearer Pelts in Game Management Unit 13, 1977-1980

Species	1977	1978	1979	1980
	Trapper Exports			
Beaver	47	24	51	48
Mink	56	105	140	163
Muskrat	525	762	632	473
Marten	61	119	194	102
Otter	3	2	10	10
White fox	2	0	11	1
Other fox	146	302	192	207
Weasel	3	38	29	2
Lynx	78	60	42	53
Number of trappers	40	57	62	39
	Dealer Purchases			
Beaver	22	11	32	9
Mink	39	42	54	102
Muskrat	552	1,023	351	805
Marten	79	273	280	236
Otter	3	7	2	2
White fox	0	0	2	2
Other fox	124	166	59	142
Weasel	32	10	50	9
Lynx	47	39	14	49

Source: Exhibit E, Vol. 7, Chap. 5, Table E.5.52.

No peregrine falcon were observed during 1980-1981 surveys in the vicinity of the proposed dams, reservoirs, and access routes, although peregrine occasionally have been observed in the area in the past (Kessel et al., 1982). In general, the area is not considered to be of high quality as peregrine breeding habitat (U.S. Fish and Wildlife Service, 1982).

K.2.1.2 Lower Susitna River Basin

The lower Susitna River Basin below Devil Canyon is inhabited by the same wildlife species as occur in the upper and middle basin area (Selkregg, 1974; Alaska Dept. of Fish and Game, 1973, 1978; U.S. Dept. of Agriculture, 1981). The abundance and relative importance of each species varies from that described above because of changes in the distribution of habitat types (see Appendix J). Forested habitats are generally more abundant in the lower basin, whereas tundra habitats are less abundant. Thus, tundra species such as caribou are not as common in the lower as in the upper and middle basin of the Susitna River. In addition, wetlands habitat becomes more abundant as the river broadens and approaches the Cook Inlet.

K.2.1.2.1 Moose

Moose are the principal big game species that will be affected by alteration of downstream flows. From 260 to 930 moose were observed during winter aerial surveys from Devil Canyon to the Cook Inlet (Modafferi, 1983). Moose were more prevalent in lower reaches than between Devil and Montana creeks. From Devil Canyon downriver toward Cook Inlet, estimated winter moose densities increased from about 3.5 to 10 individuals/mi^2 (1.5 to 4/km^2). Ratio of calves to cows observed in 1981 indicated that the population in the lower basin was somewhat more productive than the upstream population. Circumstantial evidence suggests that bear are the major predators on moose in this region (Modaferri, 1982).

Modafferi (1983) reported that moose wintering along the Susitna River annually range over an area of about 3,450 mi^2 (8,950 km^2). Most of the individual moose tracked by Modafferi (1983) overwintered in the riparian habitat in the Susitna River floodplain (Fig. K-16). Modafferi identified nine subpopulations of moose that overwinter in the riparian zones of the river. Two subpopulations remain near the river throughout the year; the others disperse from the river during summer through fall months (Fig. K-17). During calving, the subpopulation north of Talkeetna remained near the river, while others dispersed (Fig. K-18).

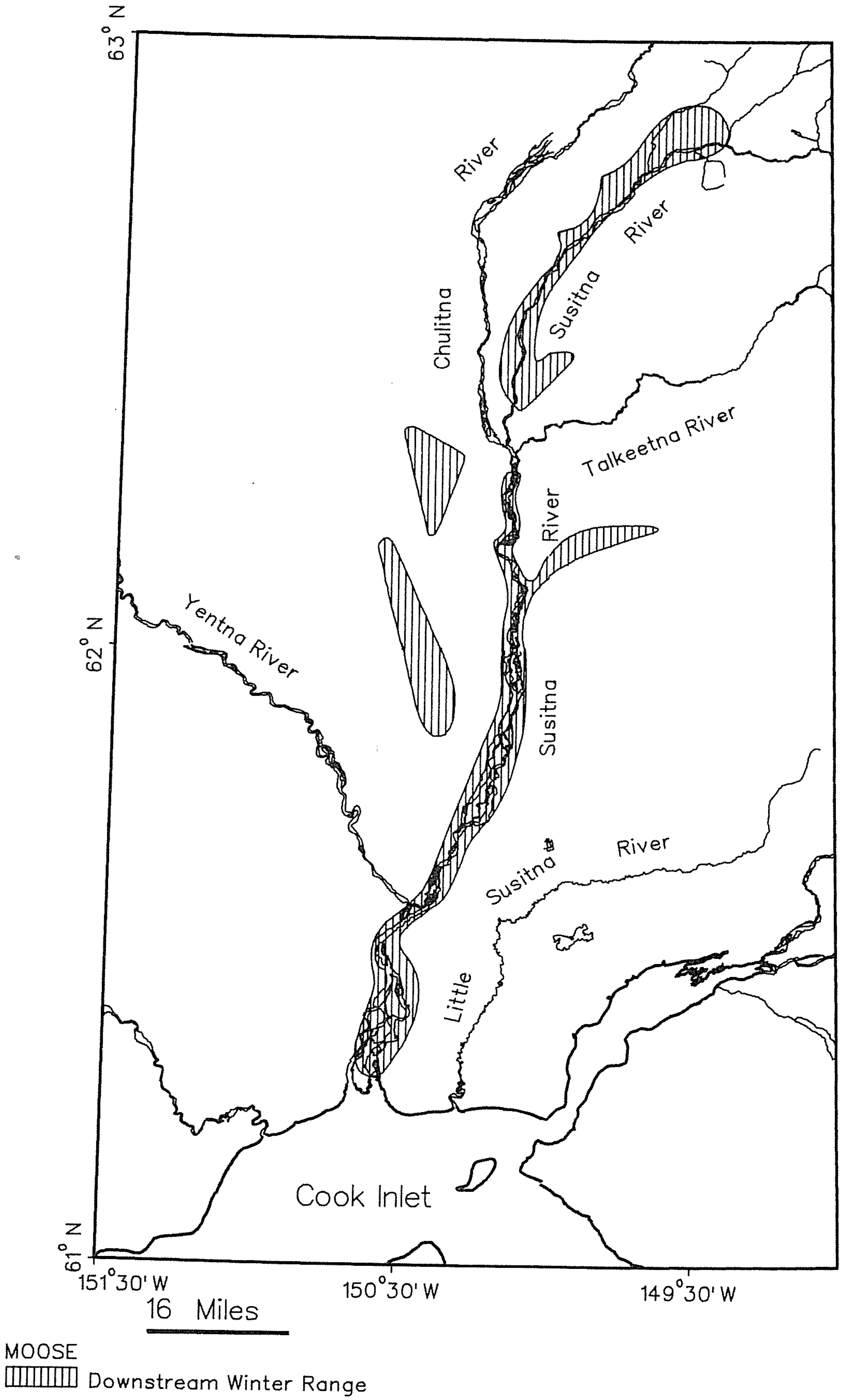

Figure K-16. General Overwintering Range of Moose in the Lower Susitna Basin. [Source: Modafferi, 1983]

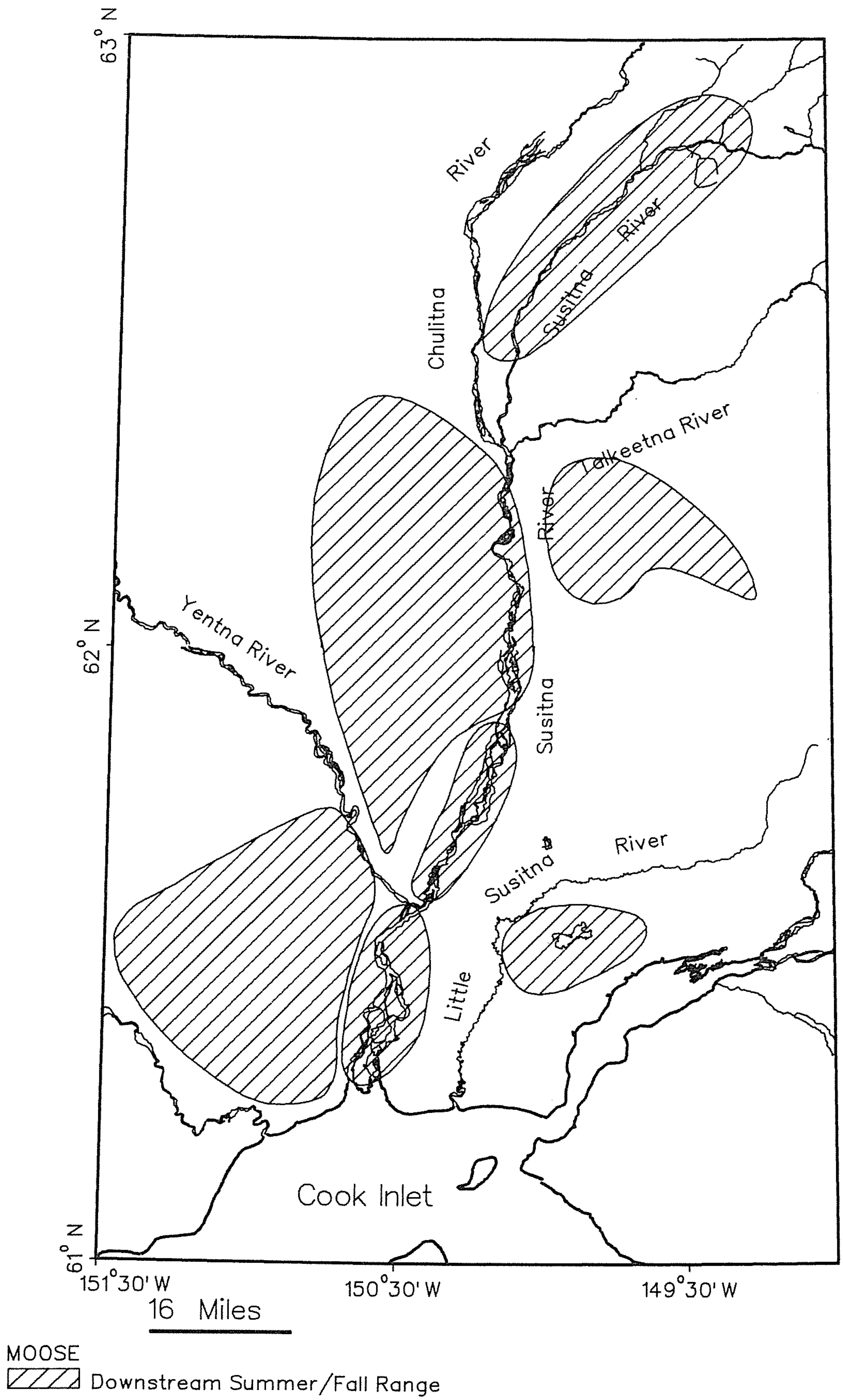

Figure K-17. General Summer-Fall Ranges of Moose in the Lower Susitna Basin. [Source: Modafferi 1983]

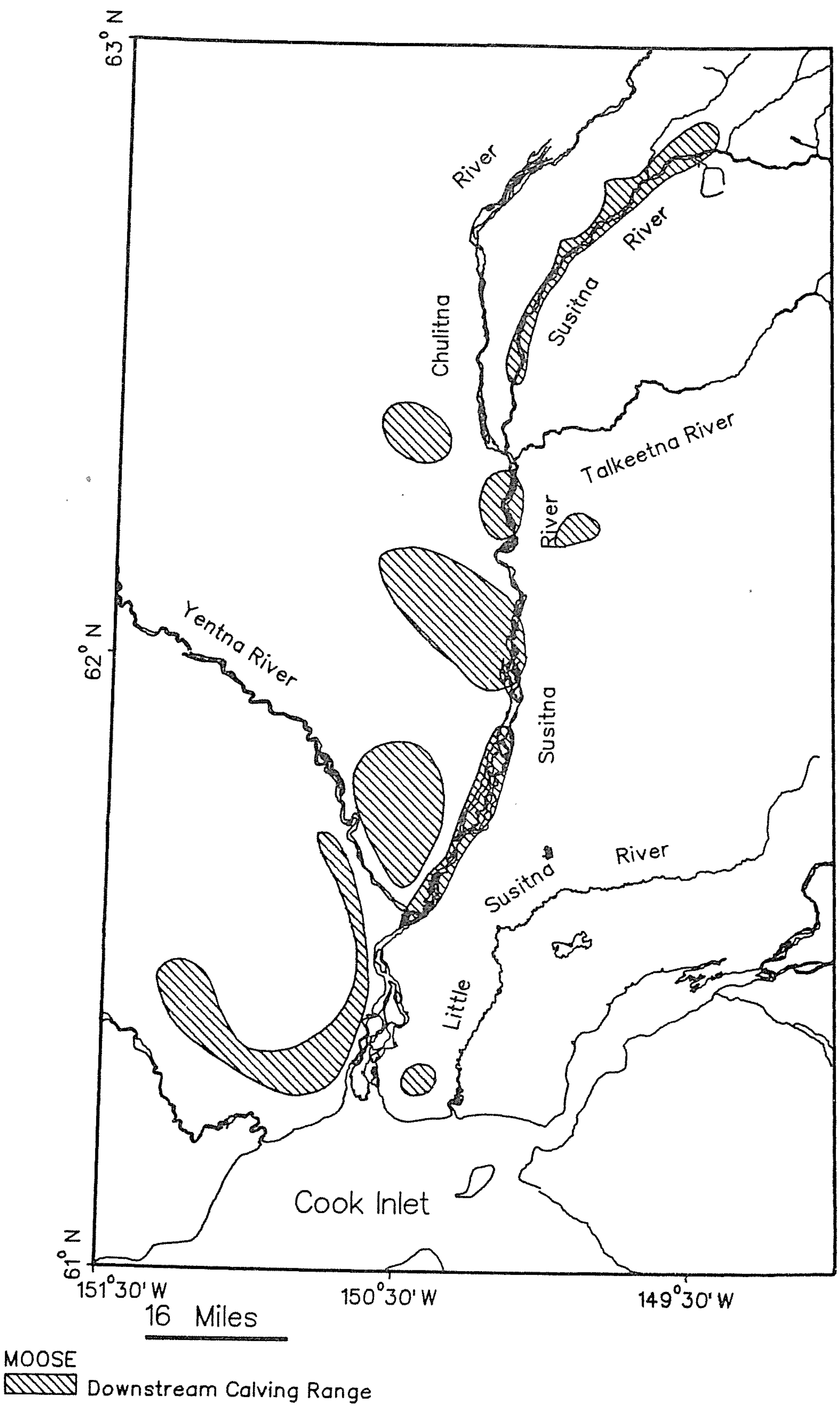

Figure K-18. General Calving Range of Moose in the Lower Susitna Basin. [Source: Modafferi 1983]

K.2.1.2.2 Bear

Black and brown bear range through the lower Susitna Basin (Selkregg, 1974; Alaska Dept. of Fish and Game, 1973, 1978; U.S. Dept. of Agriculture, 1981). Black bear are more characteristically associated with forested habitat and, hence, are more widespread in the lower basin than in the upper and middle Susitna Basin. Brown bear are more characteristic of upland, open habitats, which are not as common in the lower basin as upstream. Miller (1983) suggests that habitat becomes more suitable for black bear and less suitable for brown bear as one progresses south along the Susitna River downstream from Indian River.

Both black and brown bear fish in salmon spawning streams (July-August) and sloughs along the mainstem Susitna River. Miller (1983) indicates that brown bear used the area from Indian River to Devil Canyon (including Portage Creek) most intensively. Fishing activity of black bear increased along the Susitna River as activity of brown bear declined. Use by bear of spawning areas was correlated with the prevalence of salmon.

K.2.1.2.3 Furbearers

Gipson et al. (1982) surveyed the lower basin by air for signs of beaver and muskrat. Beaver were found to prefer slow-moving side-channels or sloughs as well as the mouths of tributaries (Exhibit E, Vol. 6A, Chap. 3, Table E.3.118). Beaver sign increased progressively farther downstream. An estimated 70 beaver inhabited the stretch from Talkeetna to Portage Creek in 1982 surveys; surveys farther south were inhibited by flooding. Muskrat were only observed south of Talkeetna and increased downstream where numerous side channels and sloughs occurred. Other furbearers occur along the lower reaches of the river but are not as likely to be affected by altered river flow regimes.

K.2.1.2.4 Raptors

In general, the lower basin does not have suitable habitat for cliff-nesting raptors such as golden eagle. In contrast, the bald eagle habitat is improved in comparison with the upper and middle Susitna Basin. The abundance of aquatic and wetland habitat provides a food base for bald eagle. In particular, salmon runs below Devil Canyon are of likely importance. Abundant tall trees along the river bank and on islands provide suitable locations for nesting and perching by bald eagle.

K.2.1.2.5 Waterbirds

The coastal wetlands provide a large area of habitat for an abundance of waterbirds (Selkregg, 1974; Sellers, 1979; U.S. Dept. of Agriculture, 1981). The Susitna River delta supports a very high density of waterfowl. This area is managed as the Susitna Flats State Game Refuge. Summer bird densities in Cook Inlet estuaries are on the order of 200 to 600 ducks/mi^2 (80-230/km^2), 20 to 100 geese/mi^2 (10-40/km^2), and 60 to 300 shorebirds/mi^2 (20-100/km^2) (Sellers, 1979).

K.2.1.3 Power Transmission Line Corridor

The proposed transmission line corridor traverses a number of habitats characteristic of Southcentral and Interior Alaska (see Appendix J). Habitats range from open tundra to closed coniferous and deciduous forest. Wildlife along the proposed route include all of the species discussed in previous sections. The abundance of species over the proposed route varies with variation in habitat distribution.

South of Gold Creek the proposed route extends through the lower Susitna River drainage, through wildlife range described in Section K.2.1.2. Black bear and moose are the most important big-game species in this area. Beaver are important furbearers along the slower waterways and in wetland areas. Marten are characteristic of coniferous and mixed forest habitats. Southward along the proposed route, waterbird densities increase as availability of suitable wetland habitats increases. The coastal wetlands between the Susitna delta and Knik Arm support extremely high densities of migratory waterfowl. Some trumpeter swan nesting and summer use areas occur along this portion of the route (Commonwealth Assoc., 1982). Bald eagle habitat also increases along the southern portions of the route.

From Gold Creek to Healy, the proposed route extends through more upland habitat (Appendix J). The wildlife characteristic of open habitats are more abundant in this area (Tarbox et al., 1979; Commonwealth Assoc., 1982). Caribou are more abundant than farther south, especially north of Broad Pass. Brown bear are also more active in this area than south of Gold Creek. Near the confluence of the Susitna and Indian Rivers, both brown and black bear use sloughs and streams as fishing grounds during salmon spawning. Suitable fishing areas also occur in the drainage of the Chulitna River. Dall's sheep are restricted to the rugged terrain south of Healy and east of Denali National Park and Preserve. This area also contains suitable habitat for cliff-nesting raptors, such as golden eagle, gyrfalcon, and goshawk.

North of Healy, moose and black bear become the most abundant big game. Suitable cliff-nesting habitat for raptors occurs along the Tanana River north of Nenana, within 5 mi (8 km) of the proposed route. Several formerly used peregrine nests are located near the proposed transmission line route, along the Tanana River north of Nenana (Exhibit E, Vol. 6A, Chap. 3, p. E-3-497; U.S. Fish and Wildlife Service, 1983c; Exhibit E, January 1984 Suppl., Response D.1).

K.2.2 Susitna Development Alternatives

K.2.2.1 Alternative Dam Locations and Designs

In general, the alternative Susitna developments (alternative locations and designs) would occur within the boundaries of the wildlife study areas described in Section K.2.1.1.

Variations of the Watana dam height (Watana I) would affect the same general wildlife populations described previously, as would alterations in the design of the proposed Watana development features. The High Devil Canyon site is located in an area of lower quality moose habitat than the Watana site and would affect the same populations affected by the upper portions of the proposed Devil Canyon reservoir (Fig. 2-17). A Reregulating dam below Watana would be located in the uppermost 10 mi (16 km) of the proposed Devil Canyon impoundment. Thus, the wildlife populations affected by the alternative locations, designs, or operation scenarios would be qualitatively the same (both upstream and downstream) as described above.

K.2.2.2 Alternative Access Routes, Power Transmission Line Routes, and Borrow Sites

All of the alternative access routes, power transmission line routes, and borrow sites (Figs. 2-2, 2-6, and 2-13 to 2-16) are within the areas covered in Sections K.2.1.1 and K.2.1.3 and the discussions of wildlife populations provided in those sections are appropriate. Access to the Parks Highway would cross wetlands between the highway and Gold Creek that are productive aquatic furbearer habitat (Acres American, 1982a). The southern alternative access and power transmission line routes between Devil Canyon and Watana would pass near Stephan Lake and Prairie Creek. The latter area has large concentrations of brown bear during salmon spawning in July and August (Miller and McAllister, 1982; Miller, 1983). That area also supports moderate to high densities of moose (Exhibit E, Vol. 9, Chap. 10, p. E-10-43).

K.2.3 Non-Susitna Generation Scenarios

K.2.3.1 Natural-Gas-fired Generation Scenario

K.2.3.1.1 Chuitna and Beluga Rivers

These alternative locations are situated west of Cook Inlet near Tyonek (Fig. 2-18). Principal big game in the area are brown and black bear and moose (Cook Inlet Reg. et al., 1981). Wolf uncommonly occur in this area. Moose are locally abundant and bear use the area on a seasonal basis.

About 150 moose were observed during a 1980 aerial survey of the area (Cook Inlet Region, 1981). Moose generally calve during spring months while in muskeg and swamp habitat. Summer months are spent in more upland habitat on the lower Chuitna River and upper Chuit Creek. Wintering grounds are located in lowland areas along Nikolai Creek and eastward from the mouth of the Beluga River. Much of the area has been logged in recent years and provide high-quality browse, particularly above Nikolai Creek.

Brown bear emerging from their dens move to lowland or mid-elevation habitat. Bear may move to areas of more concentration in order to take advantage of available prey. Bear move to higher ground as spring progresses foraging on new plant growth. During salmon spawning, bear move to several fishing areas in the drainage of the Chuitna River. In late summer bear remain near the spawning streams and supplement their diet with berries and green vegetation. Brown bear prepare overwintering dens in upland [1,000-2,500 ft (300-750 m) MSL] hillsides away from the principal alternation locations.

Black bear are found throughout the area along principal drainage (Cook Inlet Region, 1981). These bear occur principally above Nikolai Creek and in forested habitat along the upper Chuitna River. During late summer, black bear utilize the berry crop and may also concentrate along salmon spawning streams.

Bald eagles are common raptors throughout the area. Cliff-nesting raptors are uncommon. A number of waterbirds, including trumpeter swan and sandhill crane, occur in the coastal wetlands. A variety of ducks, geese, and loons are common in the area. Trading Bay State Game Refuge supports an abundant water bird population southwest of Nikolai Creek. Resident birds include common raven, chickadee, Stellar's jay, magpie, and woodpeckers.

K.2.3.1.2 Kenai

This alternative site is located on the Kenai Peninsula, east of Kenai (Fig. 2-18). The Kenai Peninsula supports a wide array of wildlife populations (Selkregg, 1974). Concentrations of moose, caribou, and waterfowl occur in all the areas with available natural gas. The area is developed for gas production and does not provide high quality habitat. An area of intensive use by black bear occurs northwest of Kenai and Soldatna. Other species occurring in the Kenai area include brown bear, Dall's sheep, mountain goat, and wolf.

K.2.3.1.3 Anchorage

This alternative site is located on the southeast site of Anchorage (Fig. 2-18). Anchorage is basically urbanized and provides limited wildlife habitat. However, moose and other wildlife do use the area on occasion. South of Anchorage, along the Seward Highway, Potter Marsh supports a large number of waterbirds.

K.2.3.2 Coal-Fired Generation Scenario

K.2.3.2.1 Willow

This alternative site is located west of Willow (Fig. 2-18). The area around Willow supports wildlife populations typical of those found along the lower Susitna drainage (see Sec. K.2.1.2). Moose concentrate along the river and near Nancy Lakes (Selkregg, 1974; U.S. Dept. of Agriculture, 1981). Black bear make intensive use of areas southwest of Willow. Waterfowl occur in low to moderate densities in the vicinity of Willow. Bald eagles and trumpeter swans nest along drainages in the area.

K.2.3.2.2 Nenana

This alternative site is located on the west side of Nenana (Fig. 2-18). The Nenana area is located in the northern third of the proposed transmission line route (see Sec. K.2.1.3). In the vicinity of Nenana, winter concentrations of moose occur along the river. Low to high densities of waterfowl are found in the vicinity of Nenana (Selkregg, 1977). The Minto Flats area to the north supports a high density of waterfowl. Two historic eyries of peregrine falcon exist on the Tanana River upstream from Nenana. The hills north of the Tanana River are considered prime habitat for peregrine falcon (Acres American, 1982a).

K.2.3.2.3 Healy

The Nenana coal-field near Healy is at the south end of the northern transmission line stub (see Sec. K.2.1.3, Fig. 1-14). Nearly 40 species of animals occur in the region (Tarbox et al., 1979). Moose are the principal big game, ranging throughout the area. The moose population is low with densities around 8 moose per 10 mi^2 (3 per 10 km^2) (Gasaway et al., 1983). Moose tend to concentrate along the river during spring calving and winter. Caribou also range through the upland habitat around the mine. Portions of several herds have historically wintered in the vicinity of Healy (Hemming, 1971). Bear and wolf also range through the area, but apparently are not abundant.

Five to ten miles (8-16 km) south of the Healy area, Dall's sheep range through the rugged uplands east of Denali National Park and Preserve (Commonwealth Assoc., 1982). This area contains all the required habitat features for sheep, e.g., mineral licks, winter cover, and hauling areas. The sheep spend spring and early summer near the Parks Highway and apparently winter to the west of the highway.

Over 50 species of birds have been recorded in the Healy area (Tarbox et al. 1979). Ducks and geese use local water bodies and wetlands. Golden eagle occur but do not appear to be abundant. Suitable cliffnesting habitat occurs in the Nenana River Gorge south of the area.

K.2.3.3 Combined Hydro-Thermal Generation Scenario

K.2.3.3.1 Chakachamna Lake

Chakachamna Lake is located west of Cook Inlet, northwest of the Chuitna and Beluga rivers (Fig. 2-18). Common mammals in the Chakachamna area are moose, black and brown bear, coyote, and gray wolf (Bechtel, 1983). River otter, barren-ground caribou, and wolverine were occasionally encountered during field surveys. Moose are common throughout the area, principally in habitat associated with drainages into Chakachamna Lake and the riparian habitats around Chakachatna and McArthur rivers. During field surveys (Bechtel, 1983), moose were abundant in the coastal marsh riparian habitat at the mouths of the rivers and less abundant in upland alder thickets on the slopes above Chakachamna Lake.

Black and brown bear were abundant in the areas above Chakachamna Lake and just downstream. High altitude riparian habitat supported the most bear (Bechtel, 1983). Bear became less common in downstream habitats along the Chakachatna and McArthur rivers. Gray wolf were commonly found in high altitude riparian habitat. Coyote were distributed over all habitats, and were abundant in coastal marsh habitat.

Coastal marsh riparian habitat supported the greatest diversity of avifauna (Bechtel, 1983). Trumpeter swan, Canada goose, marsh hawk, bald eagle, sandhill crane, and several species of gulls were commonly found in coastal marshes. This habitat also supported an abundance of ducks. Bald eagle nests were concentrated in the marsh habitat of Noaukta Slough and the lower Chakachatna and McArthur rivers. Trumpeter swan nests were most dense in an area from Noaukta Slough to Blockade Glacier along the McArthur River.

K.2.3.3.2 Browne

The Browne site is located on the Nenana River, north of Healy (Fig. 2-18). The wildlife in the area of the Browne site would be typical of those found in the central portions of the Railbelt (see Secs. K.2.1.3 and K.2.3.2.3). Important big game include moose, caribou, black and brown bear, and Dall's sheep. Moose concentrate in the general area during fall and winter (Selkregg, 1977). In winter in particular, moose tend to concentrate in riparian habitat along the Nenana River. Caribou range throughout the area, and winter concentrations are found along the Nenana. Dall's sheep concentrations are found in the highlands above the Nenana River some 10 mi (16 km) south of the site (Selkregg, 1977; Commonwealth Assoc., 1982).

Brown and black bear range throughout the area. Several miles to the south, an area around the entrance to Denali National Park and Preserve is intensively used by brown bear (Selkregg, 1977; Commonwealth Assoc., 1982). Furbearers occur along the Nenana River but do not appear to be very common.

Although waterfowl use the area along the Nenana River, densities tend to be low (Selkregg, 1977). A major flyway occurs through the area, parallel to the Nenana. Common raptors include sharp-shinned hawk, rough-legged hawk, American kestrel, and golden eagle (Armstrong, 1981; Commonwealth Assoc., 1982).

K.2.3.3.3 Keetna

The Keeta site is located on the Talkeetna River, approximately 70 mi (110 km) north of Anchorage (Fig. 2-18). The wildlife of the Keetna area are typical of those found in the middle Susitna drainage (see Sec. K.2.1.1). The site is located in an area of fall and winter concentrations of moose (Selkregg, 1977). Caribou range throughout the region, and winter concentrations occur around the potential dam sites. Concentrations of Dall's sheep are well removed, some 25 mi (40 km) to the southeast. Black and brown bear also range through the area. The brown bear fishing area at Prairie Creek is upstream of this site. This is not a major waterfowl use area.

K.2.3.3.4 Snow

The Snow site is located on the Snow River on the Kenai Peninsula north of Seward (Fig. 2-18). The riparian habitat in the Snow River supports moose and other wildlife. Upstream and downstream of the potential dam site are areas of fall and winter moose concentration (Selkregg, 1974). Mountain goat and Dall's sheep occupy the steep slopes above the site. Black and brown bear and wolf range across the area. Waterfowl use the vicinity of the site for a nesting and molting area (Exhibit E, Vol. 9, Chap. 10, Table E.10.6).

K.2.3.3.5 Johnson

The Johnson site is located on the Tanana River 120 mi (190 km) southeast of Fairbanks (Fig. 2-18). Moose and caribou range throughout the area (Selkregg, 1977), and a fall concentration area for moose is located to the southwest along the Johnson River. A bison calving area is located downstream of the site, along the Tanana River. Black and brown bear are also present (Exhibit E, Vol. 9, Chap. 10, Table E.10.6). Low densities of waterfowl use the area for nesting and molting.

K.2.3.3.6 Nenana, Chuitna River, and Anchorage

The wildlife populations of the Nenana area are as described in Section K.2.3.2, while those of the Chuitna River and Anchorage areas are as described in Section K.2.3.1.

K.3 ENVIRONMENTAL IMPACT

K.3.1 Proposed Project

K.3.1.1 Watana Development

K.3.1.1.1 Construction and Filling

MOOSE

As noted earlier (Sec. K.2.1.1.1), moose are the principal big game in Southcentral Alaska. It is anticipated that construction and filling of the Watana reservoir would have direct and indirect effects chiefly upon populations of moose upstream of the proposed dam site. Potential impacts would include loss and alteration of moose habitat and increased disturbance by human presence and activity (Table K-6).

Loss of habitat due to construction of the dam and spillways; clearing and filling of the reservoir; clearing for the camp, village and airstrip sites; and excavation of borrow areas would affect moose use of high quality habitat (see Appendix J). Approximately 37,000 acres [15,000 hectares (ha)] of land would be occupied permanently by project features (App. J, Table J-18). About another 5,200 acres (2,100 ha) would be temporarily occupied by project facilities (App. J, Table J-19). These areas would be reclaimed after they were no longer required (Exhibit E, Vol. 6A, Chap. 3, pp. E-3-275 - 278). However, recovery of the original habitat cover would not occur for a period ranging from several decades to over a century (see Appendix J).

Moose utilize all of the habitats to be affected by the Watana construction activities (Tables K-7 and K-8). Only a small percentage (ca. 1%) of the total habitat available in the upper and middle Susitna Basin would be affected by Watana construction activities (see Appendix J). However, the work of Ballard et al. (1982a, 1983a) indicates a strong preference for forested habitat (Table K-8). These are the principal habitats that would be affected by construction activities at the Watana development. The Watana development is expected to affect over 3% of the forest habitat available in the upper and middle Susitna Basin.

It is generally accepted that carrying capacity for large ungulates is limited by the availability of suitable overwintering habitat (Mautz, 1980; Hobbs et al., 1982; Potvin and Huot, 1983). This generalization is probably applicable to moose populations in Southcentral Alaska (Coady, 1982). Although winter habitat is considered limiting, it is usually only during severe winters that moose are likely to congregate in areas of low snow depths, areas of interspersion of early and late successional habitat, and areas of preferred winter browse. The Applicant's current studies have not provided a basis for evaluation of the extent of limiting winter habitat in the basin (Ballard et al., 1982a, 1983a). However, Ballard et al. (1983a) did observe about 290 moose concentrating along the Susitna and its tributaries in approximately 100 mi^2 (260 km^2) of bottomland habitat. Earlier studies and studies elsewhere suggest that during winters with heavy snowfall, the local moose utilize the mixed woodlands at lower elevations along the river and its major tributaries (see Sec. K.2.1.1.1). Approximately 8% of this bottomland forest within 10 mi (16 km) of the projected impoundment zones would be permanently occupied by Watana project features [Exhibit E, Vol. 6B, Chap. 3, Table E.3.83 (Rev.)].

Based upon preliminary calculations of winter carrying capacities, the basin has sufficient habitat to support the equivalent of 12,000 moose through the 90-day limiting winter conditions (Table K-5). This value is probably low because habitats other than coniferous or mixed forests would provide some browse. Permanent habitat lost is equivalent to an estimated winter carrying capacity of about 500 moose. Thus, construction and filling of the Watana impoundment could result in loss of carrying capacity and ultimate reduction in the moose population by about 4%. This percentage of the moose population could be higher if the projected impoundment zone contains forest habitat of higher value than elsewhere in the basin. Winter forage quality could differ among habitats, or, during winters of heavy snow, the lowlands around the projected impoundment zone could provide more protected areas with shallower snow.

Although spring use of the project area by cows with calves is widespread, Ballard et al. (1982a, 1983a) found concentrations in the primary impact zone, within the projected boundaries of the Watana impoundment (Fig. K-3). Bottomland forest habitat was a preferred habitat type during these observations. Loss of this habitat due to the flooding of the Watana impoundment, would likely have a negative impact upon successful calving and calf rearing, and, hence, recruitment of new individuals into the local population.

The magnitude of the importance of the projected impoundment zone as a calving area cannot be quantified. However, the lowland forest habitat in the impoundment zone received highest use by moose during the spring and early summer months (Ballard et al., 1982a, 1983a). Ballard et al. (1982a) postulate that these lowland habitats are sources of high-quality forage critical to

Table K-6. Potential Impacts to Moose from Watana Development

Project Features	Potential Impact
	Permanent Habitat Loss
Impoundment area and permanent facilities	Preliminary estimated loss of winter carrying capacity for the equivalent of approximately 500 moose.
	Loss of spring/early summer habitat.
	Approximately 1,800 moose would be directly affected.
	Temporary Habitat Loss
Impoundment clearing	Clearing would reduce winter and spring habitat prior to permanent loss due to flooding.
Construction areas and borrow sites	Habitat for up to 15 moose would be affected.
	Habitat Alteration
Climatic-induced habitat alteration	Delayed snowmelt would reduce the availability of low shrub habitat in spring in a narrow band on the shore of the impoundment.
	Delayed plant phenology might occur immediately adjacent to the reservoir due to its cooling effect.
Hydrologic-induced habitat alteration	Altered frequency and mechanism of creation of early successional habitats would occur in downstream reaches.
	Barriers, Impediments, and Hazards to Movement
Impoundment	Open water and/or ice shelving could impede access to traditional calving and wintering areas.
Downstream	Open water might restrict movements to island calving areas for those cows which use them.
	Attempted crossings of open water during winter might thermally stress animals.
	Ice cover and aufeis would increase downstream due to increased winter flow and might result in some mortality from moose falling down.
	Disturbance
Construction activities	Winter habitats and calving areas might be subject to disturbance.
Impoundment clearing	Noisy and unpredictable disturbances would be most serious and would likely cause avoidance of the area.
Air traffic	Overflights could be a serious impact during calving and in winter. Repeated harassment could be detrimental at all times of year.

Table K-7. Proportionate Seasonal Use of Habitat Cover Type by Radio-Collared Moose

Forest Cover Type	Proportion of Relocations†[1] Spring	Summer-Fall	Winter	N
Woodland spruce forests†[2]	0.56	0.43	0.40	791
Open spruce forests†[2]	0.29	0.28	0.30	504
Birch forests	<0.01	<0.01	<0.01	7
Mixed forests†[2]	-	-	-	-
Tall shrub†[3]	0.0	0.0	0.0	0
Birch shrub†[3]	0.0	0.0	0.0	0
Willow and mixed low Shrub†[3]	0.14	0.29	0.29	445
Tundra	0.0	0.0	0.0	0

†[1] Proportion of moose relocations in that habitat during April-May, June-October, and November-March, respectively.

†[2] Ballard et al. (1982a) included mixed forest communities in their spruce forest classifications and therefore moose use in mixed forest cover types cannot be separately estimated.

†[3] Ballard et al. (1982a) included all shrub types in a single shrub category and therefore use in various shrub types cannot be separately estimated.

Source: Ballard et al. (1982a), Table 13.

Table K-8. Moose Use of Habitat Cover Types in Relation to Their Availability within the Primary Impact Zone of the Watana Development

Cover Type	Habitat Availability	Use (%)†[1] All Moose Locations	Spring Moose Locations
Low Shrub	21.0%	23.6%	24.5%
Mat-cushion Tundra	12.5	2.3†[2]	3.0†[2]
Birch	11.1	11.9	10.7
Woodland black spruce	9.7	17.5†[2]	15.0†[2]
Open Black Spruce	6.1	12.6†[2]	12.0†[2]
Open Tall Shrub	5.7	3.8	4.7
Sedgegrass Tundra	5.4	1.7	2.6
Closed Mixed Forest	5.0	8.9†[2]	12.0†[2]
Woodland White Spruce	4.3	7.9†[2]	7.3†[2]
Sedge Shrub Tundra	3.9	0.3†[2]	-
Open Mixed Forest	3.6	2.2	2.1
Open White Spruce	2.3	2.6	1.7
Closed Tall Shrub	2.2	1.3	2.6
Rock	2.0	0†[2]	-
Lake	1.8	0.3†[2]	-
Willow	1.1	2.2†[2]	0.9†[2]
Closed Birch Forest	0.9	0.4	0.9
Open Birch Forest	0.8	0.4	-
Wet Sedge Grass Tundra	0.6	0.4	-
Totals	100.0	100.3	100.0
N	1,450 grid points	784 moose locations	233 moose locations

†[1] Includes locations on ecotones between cover types.

†[2] Use significantly different ($P<0.05$) than expected from habitat availability (X^2-test).

Source: Ballard et al. (1983a), Table 7.

recovery of nutritional balance after a severe winter. Moose and other ungulates in boreal and subarctic ecosystems are generally in a state of delicate or unstable nutritional balance at the end of a severe winter (Moen, 1978; Mautz, 1980; Coady, 1982). Lowland habitat adjacent to the river would tend to have earlier snowmelt and earlier emergence of actively growing vegetation (see Appendix J). New growth plant tissue is generally considered of high nutritional value.

The proposed Watana project could reduce the availability of spring habitat by inundation of over 55 mi^2 (140 km^2). Reduced availability of spring forage would lead to increased post-winter mortality due to exacerbation of overwintering nutritional inbalance as well as reduce productivity. These factors would further exacerbate losses of overwintering carrying capacity.

Ballard et al. (1982a, 1983a) defined three areas surrounding the impoundment as primary, secondary, and tertiary zones of impact to moose (Fig. K-19). The 1,200-mi^2 (3,000-km^2) primary impact zone was estimated on the basis of the ranges of moose that were known to utilize the areas of impoundment and project facilities. Secondary and tertiary impact zones were derived assuming that displacement of individuals from the primary impact zone would lead to an increase in competitive interactions for cover and food resources. At present, approximately 1,800 moose are estimated to use the area of the projected Watana impoundment (Ballard et al., 1983a: p. 27). Loss of this habitat for the impoundment would likely have the most direct effects upon these 1,800 moose. These moose would be compelled to compete more intensely with moose currently using range outside the primary impact zone potentially resulting in secondary effects upon an estimated 8,000 additional moose (Ballard et al., 1983a: Table 5). Although the effects of this increased competition cannot be quantified rigorously, it is likely that after establishment of the impoundment, local moose populations would stabilize at a lower level than previously.

In addition to habitat permanently lost to inundation and permanent project features, approximately 5,200 acres (2,100 ha), or 8 mi^2 (20 km^2), would be temporarily lost to project facilities. Based upon density estimates (Fig. K-2), a average of up to 15 moose would be expected to use this area of temporary disturbance. This area is located along the mainstem Susitna River and adjacent benches, although possible borrow areas extend up Tsusena Creek. Shrubland and forest habitats would be the major habitats temporarily affected (App. J, Table J-19). Temporary facilities and borrow areas not inundated would be rehabilitated within 11 years after initiation of construction (Exhibit E, Vol. 6A, Chap. 3, pp. E-3-276 to -277).

Revegetation by some plant species could occur quite rapidly on rehabilitated areas (see App. J, Sec. J.3). However, recovery of the original mosaic of mature/early successional habitats could take over 150 years. If revegetation follows the pattern of natural succession in subarctic systems, the presence of early successional stages would provide high-quality browse for local moose (Peek, 1974; Wolf, 1978; Wolff and Zasada, 1979). Based upon rates of natural succession, optimum forage would be expected to be available for about 1 to 20 years following the initiation of recovery (Wolff and Zasada, 1979). However, as Wolff and Zasada note, although the forage might be available, moose would not necessarily be able to or choose to utilize it.

The second principal impact to moose using the Watana construction zone would be disturbance of individuals due to the presence of unfamiliar and conspicuous auditory and visual stimuli. Human activities associated with the construction of the Watana development would generate an array of stimuli unfamiliar to local fauna. Moose and other game might be directly affected by the interruption of activity patterns and resulting avoidance of the construction area and imbalances in nutritional budgets.

Noise generated by urban construction activities is generally on the order of 90 decibels, A-weighted, (dBA) at a distance of 50 ft (15 m) from the equipment (U.S. Environmental Protection Agency, 1974a). Construction at the dam site would likely generate continuous noise levels on the same order of magnitude, with impulse noise ranging higher. Background levels over which these noise levels would be superimposed are on the order of 20-30 dBA for wilderness areas (U.S. Environmental Protection Agency, 1974b). Under ideal conditions, with no barriers to sound travel, construction noise could be distinguishable from background up to about 10 mi (15 km) from the construction zone. The review of Dufour (1980) suggests that ungulates are not disturbed by steady-state noise below about 60 dBA. Unobstructed sound waves would drop to this level at about 0.3 mi (0.5 km) from the construction zone. Thus, the area of continual disturbance around the construction sites and borrow areas might be on the order of 20 mi^2 (50 km^2), assuming activities extend approximately 32 mi (51 km) along the Susitna River and Tsusena Creek (Exhibit E, Vol. 9 Chap. 10, Fig. E.10.13). Impulse noise, principally due to blasting, and noise associated with aircraft would be expected to carry for longer distances. Effects from aircraft would be restricted to areas near landing sites, unless active harassment of moose occurred.

Clearing of forest prior to flooding would also generate noise on the order of 90 dBA. Disturbance affects associated with clearing would extend for the length of the projected impoundment, ca. 50 mi (80 km), affecting an area of ca. 30 mi^2 (80 km^2). Because clearing would occur progressively as the reservoir fills, clearing noise and activity would be of shorter duration (weeks) than noise and activity around the construction zone (about 10 years).

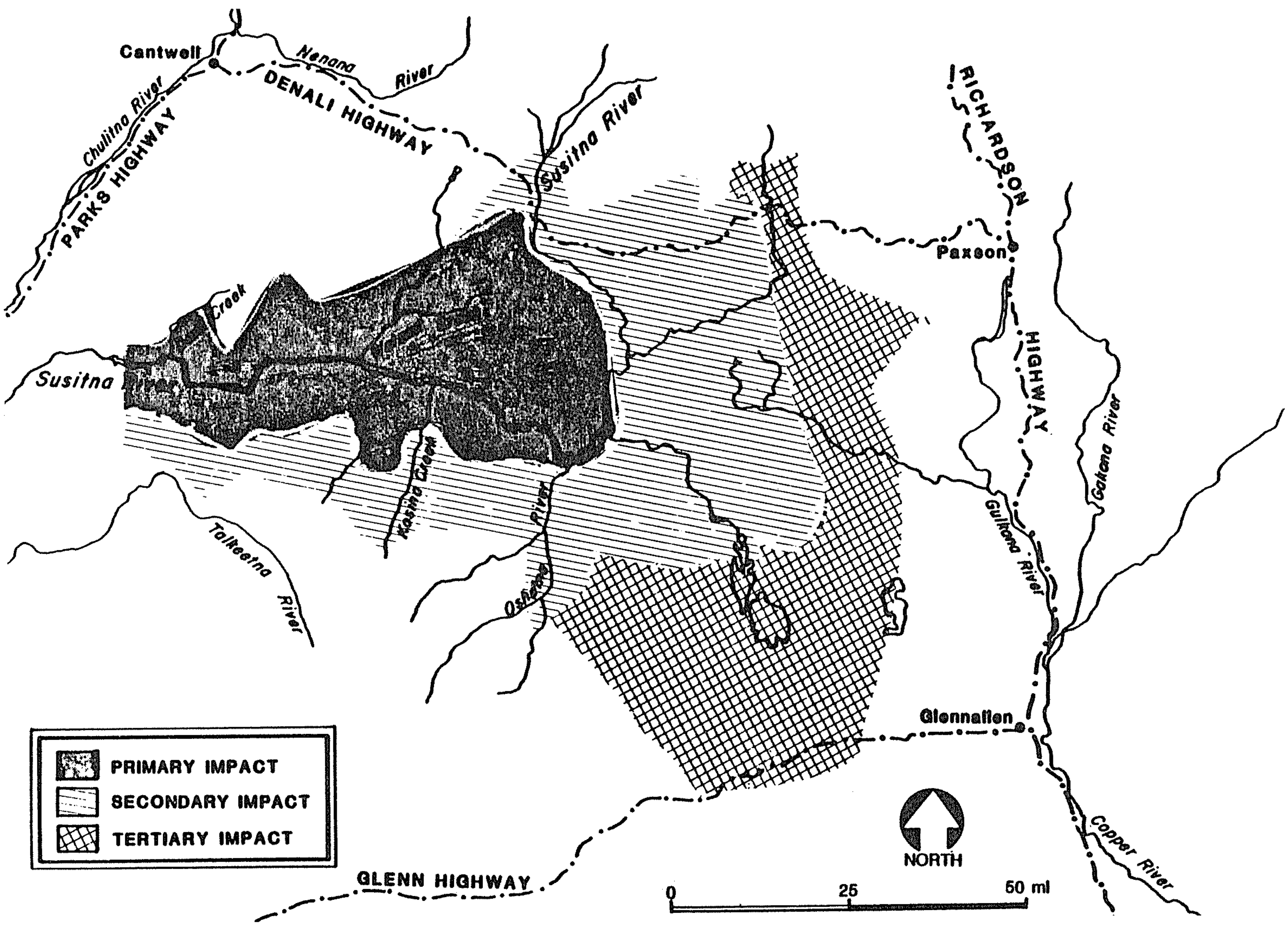

Figure K-19. Boundaries of Primary, Secondary, and Tertiary Zones of Impact for the Susitna Hydroelectric Project. [Source: Ballard et al., 1983a: Fig. 3]

The effects of disturbing stimuli upon moose are difficult to predict. The Applicant cites Tracy (1977) as evidence that moose are more tolerant of human activity than other ungulates (Exhibit E, Vol. 6A, Chap. 3, p. E-3-402). However, it is unlikely that the level of activity during Tracy's studies in McKinley National Park (now Denali National Park and Preserve) approached the levels anticipated for the Watana construction. The Applicant also cites empirical evidence that moose continue to utilize habitat in the vicinity of construction and mining activities in northern Canada (Exhibit E, Vol. 6A, Chap. 3, p. E-3-403). This tolerance of extensive activity appears to exist only if hunting and overt harassment pressures are absent.

If moose avoid the construction areas, there would be an effective reduction in carrying capacity. Displacement of moose to other areas could increase competition for habitat resources probably leading to a net loss in moose numbers in regions around the construction area. The extent of displacement would be temporary during the construction period (ca. 10 years). Even if moose do not avoid the construction area, they could be subject to stress from disturbing stimuli, particularly due to sporadic blasting and low-level overflights. Several studies have identified physiological responses to unfamiliar noise and visual stimuli in the absence of overt behavioral responses (McArthur et al., 1979; Moen et al., 1982). Moen (1976, 1978) has postulated that such responses could lead to energetic imbalances during stressful winters. This could be most deleterious during winter when mineral and energy balances are delicate for moose.

The approximately 20 mi^2 (50 km^2) zone of disturbance would extend through areas of low moose density [1.1/mi^2 (0.4/km^2)] to moderate density [1.8/mi^2 (1.4/km^2)] (Fig. K-2). Thus, some 20 to 40 moose would likely be affected by direct disturbance. The number could increase during severe winters as moose move into lowland habitat near the construction zone.

CARIBOU

Construction activities at the Watana development would remove temporarily and permanently about 52,000 acres (21,000 ha) of caribou habitat (App. J, Tables J-18 and J-19). However, the loss of this habitat would not be expected to be problematical as it represents less than 1% of the habitat available to the Nelchina herd (Table K-9). The construction and impoundment areas are not extensively used by caribou and are not considered high-quality caribou range (Pitcher, 1982, 1983). The principal effects upon caribou would be the interruption of movement by the presence of the reservoir and access route (see Sec. K.3.1.1.2).

Unfamiliar acoustic and visual stimuli might elicit fright or other stress responses from individual caribou in the proposed construction zone. Because the area is not used extensively by caribou, it is unlikely that such responses would adversely affect the Nelchina herd even if individuals are affected. Life-history stages of extreme sensitivity, e.g., calving and rearing, occur in areas well removed from the construction zone (see Fig. K-6). During the summer months, bull caribou might be found in the vicinity of the projected borrow areas A, D, and F (Figs. 2-2 and 2-6). Activities in these areas might cause a few caribou to avoid using the adjacent range. Construction effects upon the total herd would be minute.

Table K-9. Potential Impacts to Caribou from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment area	Area that would be permanently lost represents 0.3% of total range, and would consist of low-quality grazing habitat.
	Habitat Alteration and Temporary Habitat Loss:
Reclaimed areas	Borrow sites A, D, and F would be in areas frequented by bulls in summer.
	Barriers, Impediments, and Hazards to Movement:
Impoundment	Might result in: (1) altered movement patterns reducing frequency of crossing with consequent decreases in use of portions of range, thus reducing carrying capacity; (2) isolating of subherds having separate calving grounds; (3) increased accidental mortality associated with ice shelving, drifting ice flows, floating debris, and extensive mud flats.

DALL'S SHEEP

No sheep habitat would be affected by construction activities at the Watana site (Table K-10). Sheep are sensitive to disturbance from human activity; however, they do habituate to moderate levels of activity (Geist, 1980; Lawson and Johnson, 1982; MacArthur, 1979, 1982; Hicks and Elder, 1979). Although the sheep range is well removed from the construction site (Fig. K-10), some disturbance of sheep would be expected due to air traffic to and from the construction areas. Because the areas of sheep concentration are removed from the construction zone, overflights in support of construction should generally be at high enough altitudes [>1,000 ft (300 m)] to reduce harassment impacts to a minor level.

Filling of the reservoir would inundate an important mineral lick along Jay Creek (Table K-10) (see Sec. K.3.1.1.2 for further discussion).

BROWN BEAR

About 400 brown bear range throughout the 6,400-mi^2 (16,000-km^2) upper and middle Susitna Basin (Miller and McAllister, 1982; Miller and Ballard, 1982). Miller and McAllister (1982) indicate that this is probably an underestimate. The two principal impacts to brown bear would be temporary and permanent loss of spring food resources and human-bear interactions (Table K-11).

Construction and filling of Watana reservoir would inundate over 55 mi^2 (140 km^2) of brown bear habitat (App. J, Table J-18). The lowland habitats of the projected impoundment zone appear to be important sources of early spring berries to a majority of the local population (Miller and McAllister, 1982). The lowland habitats are generally the first areas to become clear of snow, providing access to over wintering berries. Plant growth begins earlier in lowland habitats as well, providing high-quality new plant growth.

Adult male and yearling bear are the principal individuals that would be impacted by the loss of lowland spring habitat (Miller and McAllister, 1982; Miller, 1983). Sows with cubs tend to remain in upland areas later than other individuals. Miller and McAllister (1982) postulate that the lowland forage plays an important role in regaining nutritional balance after overwintering. During the winter denning period, brown bear rarely venture from their dens (Craighead and Mitchell, 1982). Thus, they are dependent upon metabolism of body fat stores for maintenance of metabolic energy needs. During the course of a winter, a brown bear may lose in excess of 30% of its pre-denning body weight. Thus, the period immediately after emergence is a critical period in initiating the recovery of fat stores metabolized during denning.

The extent to which brown bear in the basin are dependent upon moose is not clear. Animal matter makes up the majority (50%-60%) of the brown bear diet (Craighead and Miller, 1982). Ballard et al. (1981a) found that a large proportion (>40%) of moose-calf mortality could be attributed to brown bear predation. However, the proportion of moose in the brown bear diet is not known. Because moose are the most prevalent ungulates in the area, it is likely that they form a large proportion of the animal matter in the diet of local brown bear. Thus, effects upon the moose population size would probably result in the reduction of the overall food base for brown bear in the basin.

Construction activity would likely increase interactions between bears and humans, as well as influence some bears to avoid the area of human activity. Those bear that became habituated to human presence might become pests if they were attracted to accessible food such as garbage. These individuals could engage in actions leading to property damage, to injury to humans and to themselves, and to mortality of problem bears. Proper handling of putrescible wastes would reduce the potential for persistent encroachment by problem bears into human work and living areas. Habituated bears might also become more susceptible to hunting (see Sec. K.3.1.1.3). Chance, surprise encounters of bear and humans could also have injurious or fatal results for either party. Because construction activities would affect a small area and a small number of bears (on the order of ten), these human/bear interactions due to construction activities would be unlikely to have a major impact upon the bear population of the basin. Interactions could, however, have disruptive effects on human activities.

BLACK BEAR

In the upper and middle Susitna Basin, black bear are generally found in lowland conifer habitats along the Susitna River and its tributaries (see Sec. K.2.1.1.5). Most sightings of black bear have been within a 10-mi (16-km) strip on either side of the Susitna River from Gold Creek to the MacLaren River (Miller and McAllister, 1982: Fig. 2). Only during the late summer berry season do black bear venture onto the tablelands north of the Susitna. Miller and McAllister (1982) estimated that on the order of 300 to 400 black bear occupy the vicinity of the projected Watana impoundment.

Table K-10. Potential Impacts to Dall's Sheep from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment	Inundation of over 22% of Jay Creek mineral lick during months of maximum use. At maximum impoundment level in October, 42% of lick surface would be be flooded.
	Habitat Alteration and Temporary Habitat Loss:
Impoundment	Areas of lick below maximum fill level might suffer some leaching, making them less desirable when they are available.
	Disturbance:
Air traffic	Impacts to all Dall's sheep in the middle basin might occur if low-flying aircraft are uncontrolled. The Jay Creek mineral lick would be a particularly sensitive area.

Table K-11. Potential Impacts to Brown Bear from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment	Spring feeding areas (lower elevation spruce habitats) would be flooded.
	Effects on prey populations might impact brown bears, but the importance of ungulate prey is unquantified.
	Habitat Alteration and Temporary Habitat Loss:
Hydrologic-induced	Reduction in prey populations (ungulate and salmon) if they occur would impact brown bears in downstream reaches.
	Barriers, Impediments, and Hazards to Movements:
Impoundment	Broken ice and/or ice-shelving might block or hinder access to habitually used areas for some individuals in early spring.
	Disturbance:
General	Some bears would avoid areas of intense human activities; others would habituate and some habituated bears might be attracted to such areas.
	Human/bear conflicts would have a potential to cause significant loss of work time for contractors, injuries to employees, and property damage.
	Habituated bears also might become more susceptible to hunting.
Impoundment facilities, staging areas, borrow sites	Mortalities due to human/bear conflicts.
	Altered movements due to avoidance or attraction.
	Bears would be attracted to garbage dumps and to improperly disposed or inadequately incinerated garbage.
	Bears might be attracted to revegetated areas. This would increase their contact with humans, causing problems with habituated bears.
Air traffic	Might disrupt normal feeding, resting, and denning activities.

Filling the Watana impoundment would be expected to inundate about 8% of the suitable forest habitat available for black bear within the upper and middle basin (Table K-12 and App. J, Table J-18). Such loss could be directly reflected in a concomitant reduction in the local black bear population.

The most severe effects would likely result from loss of suitable habitat for locating black bear dens (McAllister and Miller, 1982; Miller, 1983). Of 24 dens in the locality of the projected Watana impoundment, 13 would be inundated. Thus, the impoundment would severely restrict the availability of suitable denning sites in the area, perhaps by as much as 55% (Table K-12).

Loss of suitable habitat would be likely to cause some black bear to shift activities to more upland locations. Such shifts would increase the probability of interactions with the larger brown bear. Increased interaction could lead to increased mortal or debilitating injury as well as reduced nutritional status. This situation would further exacerbate the direct effects of impoundment, along with effects of increased human activity and hunting pressure (discussed in Sec. K.3.1.1.3).

Disturbance and human/bear interactions would be of the same nature as described for brown bear. However, a greater number of individual black bear are likely to be involved in such interactions because of the concentration of suitable black bear habitat around the construction area. Again, movement of black bear from the construction area to the fringes of suitable habitat would likely bring black bear into contact with brown bear more frequently.

WOLF

The Watana and Jay Creek packs and possibly the Talkeetna River pack could be affected by construction and filling activities (Ballard et al., 1982d, 1983c). No known denning or rendezvous areas would be affected by construction (Table K-13). However, loss or displacement of moose and caribou prey from the construction area could lead to loss of carrying capacity for wolf in the construction zone.

Construction, clearing, and impoundment filling would affect over 55 mi^2 (140 km^2) of area within the home ranges of the Watana and Jay Creek packs, containing up to 16 and 12 individuals, respectively. The territories of these packs average about 500 mi^2 (1,300 km^2) for the Watana pack and about 150 mi^2 (390 km^2) for the Jay Creek pack (Ballard et al., 1982, 1983c). Thus, about 7% of the territories of these two packs would be lost, leading to a reduction in hunting range, impedance of movement, and reduction of abundance of prey. The area that would be inundated is centered in the portion of the territories receiving highest (45%) use (Ballard et al., 1983b). Thus, the size of these two packs could be substantially reduced if the two packs were able to survive as separate entities.

The displacement or reduction in numbers of prey in the impoundment area would have a negative impact on wolf using the impoundment area (Ballard et al., 1982d, 1983c). This is particularly true since moose calving and rearing grounds would be lost to inundation (Table K-6). Although the impoundment might increase the susceptibility of some ungulates to wolf, the net result over the long term would be a reduction of carrying capacity for wolf prey in the vicinity of the impoundment.

Data of Van Ballenberghe et al. (1975) and Gasaway et al. (1983) indicate that food supply is generally the major factor limiting wolf populations. However, the population in the basin is believed to be currently limited by hunting (Ballard et al., 1981, 1982d, 1983c; Gasaway et al., 1983). Thus, a reduction in food supply would not be expected to result in a depression in local wolf numbers. On the other hand, the Watana pack is less accessible to hunting than more peripheral packs in the basin, and Ballard et al. (1983c) suggest that this productive pack serves as a reservoir for recruitment of young into other packs. Thus, impacts to the food supply of the Watana pack could affect recruitment of wolves into more heavily hunted packs and result in a subsequent decline in the basinwide wolf population. The extent to which the Watana pack serves as a reservoir for recruitment of wolves into other packs is not known.

In order to avoid human activity or in order to find more prey, the Watana and Jay Creek packs might shift their ranges in response to construction activities. This would likely lead to increased interaction and competition with adjacent packs, possibly leading to a net loss in wolf numbers. Some wolves might habituate to the presence of humans and become nuisance animals. Nuisance interactions with humans would be likely to lead to the mortality of some wolf in the construction area.

WOLVERINE

An estimated 80 wolverine occupied the upper and middle Susitna Basin in 1980 to 1982 (Whitman and Ballard, 1983). Of 12 wolverine monitored in the basin, only two had ranges overlapping the construction and impoundment zone.

Table K-12. Potential Impacts to Black Bear from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment area	About 8% of pine spruce forest habitats would be lost. The narrow band of spruce forest remaining could leave resident bears susceptible to interactions with brown bears and necessitate altered movement patterns.
	Den habitats (55% of known dens) would be flooded.
	Habitat Alteration and Temporary Habitat Loss:
Reclaimed areas	Borrow areas D and F would be in areas used for berries in late summer. Revegetation would be likely to improve availability of early spring forage temporarily.
Impoundment shore erosion	Possible impact to some den habitats.
Hydrologic-induced alteration	Reduction in salmon populations (if they occur) would negatively impact black bears.
	Alteration of hydrologic regime might alter availability of riparian spring forage.
	Barriers, Impediments, and Hazards to Movement:
Impoundment	Broken ice floes and/or ice shelving might hinder access to habitually used areas for some individuals in early spring.
	Animals displaced during filling could be susceptible to mortality from brown bears they may encounter on dispersal.
Operating facilities	Might block access or alter movements of downstream animals to late summer foraging areas upstream of Tsusena Creek.
	Disturbance Related to Construction Activities:
Impoundment facilities, staging areas, and borrow sites	Mortalities due to human/bear conflicts.
	Altered movements due to avoidance or attraction.
	Individual bears whose home ranges overlap these sites would be displaced.
	Bears would avoid denning near areas with frequent disturbances.
	Bears might be attracted to revegetated areas. This would increase their contact with humans and cause problems with habituated bears.
Air traffic	Might disrupt normal feeding, resting, and denning activities.

Table K-13. Potential Impacts to Wolf from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment and facilities	Watana pack members might be affected because 45% of all radio-locations for pack members were in the impoundment zone.
	Secondary effects of the elimination of the Watana pack's range would be upheaval of the historical distribution of packs and associated social strife.
	Reductions in moose carrying capacity would reduce wolf carrying capacity, though wolves have not obtained carrying capacity in the basin for several decades due to wolf-control measures, hunting, and trapping.
	Habitat Alteration and Temporary Habitat Loss:
	Reduction in carrying capacity of prey would reduce capacity for wolves.
	Barriers, Impediments, and Hazards to Movement:
Impoundment and facilities	Might reduce access to caribou and moose calving areas for some packs.
Downstream reaches	Open water in winter might be a hazard to wolves attempting to cross.
	Disturbance:
Construction activities	Avoidance would occur initially, but habituation to predictable disturbances might occur.
	Den sites are most sensitive and wolves would abandon dens that were disturbed frequently.
	Habituated wolves would have the potential to become nuisance animals.
Air traffic	Den sites would be abandoned if frequent air traffic occurred at low altitudes near dens.

Impacts would be manifested through loss of over 55 mi^2 (140 km^2) of foraging habitat and disturbance from human activity (Table K-14). Principally forested, winter habitat would be inundated (App. J, Table J-18). This would result in the loss of small mammal and bird prey for a few wolverine. Based upon the estimate of 1 wolverine/60 mi^2 (1/160 km^2), loss of the inundated area of 55 mi^2 (140 km^2) would lower the carrying capacity by the equivalent of about one wolverine (Whitman and Ballard, 1983).

Loss of moose overwintering habitat due to impoundment might lead to increased mortality and consequent increased availability of moose carrion. This would benefit some wolverine by providing additional food base. However, the long-term availability of added carrion would vary as nutrition-induced mortality of moose varied with winter severity.

Human activities in the construction and impoundment zones would likely cause wolverine to avoid the area for the duration of activities (about ten years). Several (10 to 20) wolverine could be affected by these activities (Gardner and Ballard, 1982; Whitman and Ballard, 1983). Shifts in territory use could increase competitive and aggressive interaction among individual wolverine.

BEAVER AND MUSKRAT

No beaver would be affected by construction and filling activities (Gipson et al., 1982; Table K-15); however, five to ten muskrat use borrow areas D and E for overwintering (Figs. 2-2 and 2-6). Impacts of construction to the basinwide population of muskrat would be minor because of the small number of muskrat involved.

Table K-14. Potential Impacts to Wolverine from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment area	Wintering foraging habitat would be lost, with a substantial decrease in availability of small mammal and grouse.
	Barriers, Impediments, and Hazards to Movement:
Impoundment	Might form home range boundaries for animals in basin.
	Disturbance:
All construction areas and impoundment clearing	Wolverine would be likely to avoid all areas of active disturbance.

Table K-15. Potential Impacts to Aquatic Furbearers from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment	About 5-10 muskrats would be disturbed in the impoundment and borrow areas D and E.
	Habitat Alteration and Temporary Habitat Loss:
Hydrologic-induced alteration	Increased winter flows would likely benefit beaver, allowing over-wintering in more sites than are currently available.
	Stabilized flows would allow beaver greater security in anchoring food caches.
	Lack of ice cover would allow colonization of shallower reaches.
	Muskrat would likely benefit from increased number of beaver ponds down-stream.

MINK AND OTTER

Mink and otter generally prefer habitat along slow- to moderate-flowing rivers and streams with well-wooded banks. Such habitat exists along the Susitna River and its tributaries above the Watana dam site. Gipson et al. (1982) found that river otter were common in the upper and middle Susitna Basin. Mink were locally abundant near some streams and lakes. Filling of the Watana impoundment would inundate some 60 mi (100 km) of suitable habitat for these species.

Mink and otter would likely be affected by activities along streams and the river mainstem (Table K-16). Activities in the borrow areas could lead to disruption of up to about 3,000 acres (1,300 ha) of habitat suitable for supporting these species (App. J, Table J-19). Clearing and inundation of forest habitat would affect the availability of terrestrial prey such as small mammals and waterfowl. Activities would affect aquatic prey as well through siltation of streams.

RED FOX AND COYOTE

Although prey-supporting habitat might be lost, no important components of the prey bases of red fox and coyote would be lost during construction and filling. Some prey habitat would be lost to clearing and inundation of some 55 mi^2 (140 km^2) of habitat (Table K-17). Most red fox utilize areas above the impoundment zone during the winter season of limited food availability (Gipson et al., 1982). During the other seasons, abundant small mammal and bird prey would continue to occur in habitats adjacent to the reservoir. Both fox and coyote might habituate to human presence and become nuisances at construction sites. Wolf could prevent coyote from using project areas unless wolf were eliminated from the area.

MARTEN, WEASEL, AND LYNX

Marten, weasel, and lynx would be affected by the loss of forested habitat due to the Watana impoundment. Gipson et al. (1982) estimated that habitat supporting up to 100 marten would be lost. Weasel are abundant, but only a small fraction of their available habitat would be affected. Lynx are not abundant in the basin and few would be affected.

RAPTORS AND RAVENS

The principal impacts to raptors and ravens in the vicinity of the Watana impoundment would be loss or disturbance of nesting locations (Table K-18). The major raptors of concern include golden eagle, bald eagle, goshawk, and gyrfalcon. The peregrine falcon is endangered in Alaska and is discussed in Section K.3.1.1.3. Golden eagle, gyrfalcon, and raven nest in riverine and upland cliffs (Kessel et al., 1982; Armstrong, 1981; Bent, 1961). Bald eagle and goshawk commonly nest in mature trees.

Construction activities could affect about 30 out of 50 raptor and raven active nesting locations (Table K-19). Of these, only one golden eagle nest would be destroyed by activities within borrow site E (Fig. 2-6). A number of other nesting locations would be inundated during reservoir filling, including 5 or 6 golden eagle sites, 4 bald eagle sites, 1 goshawk site, and 15 raven sites. Thus, approximately half of the known raptor and raven nesting locations would be lost during construction and filling of the Watana development. In addition to loss of known nesting locations, filling of the Watana reservoir would result in loss of potential nesting habitat. About 9 mi (15 km) of good-quality cliff nesting habitat would be flooded, leaving only 0.6 mi (1 km) above Watana dam (Kessel et al., 1982). Because much of the area that would be flooded is forested (ca. 75%) a large proportion of suitable tree nesting habitat would be lost as well. Availability of suitable nesting habitat is often a factor in limiting the numbers of raptors (Newton, 1979: pp. 71-73).

In the Susitna Basin, the gyrfalcon is at the southern extreme of its range (Bent, 1961; Armstrong, 1981; Peterson, 1961). Hence, loss of suitable nesting locations along the Susitna River would not have a major impact on the species as a whole within Alaska.

In contrast, a large proportion of the suitable nesting locations for golden eagle in Southcentral Alaska occurs along the middle Susitna River and would be impacted (Exhibit E, Vol. 6A, Chap. 3, p. E-3-444). Thus, severe impact to golden eagle would be anticipated. Suitable nesting locations for bald eagle and goshawk are limited above Devil Canyon, and the principal concentrations of these raptors are situated downstream. Thus, impacts to these species would be expected to be minor. Raven nest in a variety of situations and are common throughout Alaska. Impacts to this species would also be relatively minor.

Of lesser concern would be the loss of perching and hunting habitat. Raptors are limited by the availability of food as well as availability of nesting locations (Newton, 1979: pp. 61-71). However, loss of hunting territory is likely to be of only minor consequence in the basin. Golden eagle, gyrfalcon, and goshawk tend to hunt in open, treeless areas or along the forest edge (Bent, 1961; Armstrong, 1981). These cover types would not be greatly affected by the impoundment (see Appendix J). Bald eagle hunt over the open waters of the Susitna and its major

Table K-16. Potential Impacts to Semi-Aquatic Furbearers (mink and otter) from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment area and permanent facilities	Would eliminate a substantial portion of good-quality habitat for both species, 50 mi of mainstem plus 10 mi of stream habitat.
	Would reduce prey availability for both species.
	Habitat Alteration and Temporary Habitat Loss:
Hydrologic-induced alteration	Downstream flow stabilization and open water would benefit otter and mink. Increased number of beaver would benefit both.
	Disturbance:
Construction sites	Might disturb daily activities and force abandonment of aquatic habitats where they occur near construction zones.

Conversion: To convert miles to kilometers, multiply by 1.61.

Table K-17. Potential Impacts to Fox from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment and other facilities	Fox would lose some prey.
	Barriers, Impediments, or Hazards to Movement:
Impoundment	Might serve as home range boundary for resident animals, but would not prohibit movements across impoundment.
Downstream	Open water in winter might make crossings hazardous or infrequent.
	Disturbance:
	Den sites would be sensitive to disturbance, particularly during early denning and early postpartum.
	Habituated foxes could become pests, leading to increased probability of exposure to rabies.

Table K-18. Potential Impacts to Raptors and Ravens from Watana Development

Project Features	Impacts
	Permanent Habitat Loss:
Impoundment	5-6 of 16 (31%) golden eagle nesting locations would be lost.
	Cliff nesting habitat would become extremely limited.
	4 of 8 (50%) bald eagle nesting locations would be lost.
	1 of 3 (33%) known goshawk nesting locations would be lost.
	Perching habitat on cliffs and large trees would be lost. Some hunting habitat would also be lost, although this is not expected to be a significant impact on any of the raptor species.
	Habitat Alteration:
Borrow sites reclaimed areas.	A golden eagle nesting location would be destroyed by borrow area E.
	Disturbance Related to Construction Activities:
Impoundment clearing	7 golden eagle nests susceptible to disturbance during clearing.
	4 bald eagle nests susceptible.
	1 gyrfalcon nest susceptible.
	1 known goshawk nest susceptible.
	12 raven nests susceptible.
Borrow sites	Golden eagle nest susceptible at borrow site E; might be destroyed.
	1 goshawk nest susceptible at borrow site I.
	2 raven nests susceptible at borrow site H.
Air traffic	Golden eagles particularly susceptible during nestling period. Other raptors susceptible but somewhat less sensitive.
Borrow sites	1 gyrfalcon nest susceptible in borrow site K.

Table K-19. Raptor and Raven Nesting Locations that Might Be Affected by Construction Activities at the Watana Development

Species	Number of Locations	Total Known in Basin	Project Effects
Golden eagle	9-10	16	2 locations are situated <0.1 mi from borrow site J; 1 within 1 mi of borrow site F; 1 lies within borrow site E; 5-6 would be inundated.
Bald eagle	4	8	In undation zone.
Gryfalcon	0	3	
Goshawk	2	3	1 located within 0.1 mi of borrow site I; 1 within inundation zone.
Raven	15	21	2 are located within 330 ft of borrow site J; 1 <0.1 and 1 <1 mi from borrow site H; 2 within 1 mi of the Watana camp; 10 within inundation zone.
Totals	30-31	51	

Conversion: To convert miles to kilometers, multiply by 1.61.

tributaries. The reservoir might have some suitable habitat for fish or waterfowl prey, but reservoir dynamics would be unlikely to allow large numbers of prey to be present. Thus, losses of hunting habitat would likely be greater for bald eagles than for other raptors.

About ten nesting locations would be subject to disturbance by human presence. The responses of raptors to disturbance are variable (Table K-20). The net result of such disturbance could be loss in productivity and lower recruitment of young into the population. Several studies have recorded evidence of reduced productivity and recruitment by raptors in response to human-induced disturbance (Swenson, 1979; Grier, 1969). Stalmaster and Newman (1978) reported alteration in patterns of use by wintering bald eagles. Eagles tended to be displaced from areas of higher human activity in response to the presence of humans. In contrast, Mathisen (1969) and McEwan and Hirth (1979) reported no correlations between bald eagle productivity and human activity.

Citing Roseneau et al. (1981), the Applicant notes that although raptors may habituate to disturbances in some cases, in other cases the same level and types of disturbance elicit detrimental responses (Exhibit E, Vol. 6A, Chap. 3, p. E-3-452). Golden eagle appear most susceptible to disturbance, particularly by aircraft overflights and human presence. Prolonged or multiple disturbances and overt harassment are especially effective inducers of deleterious responses. Although management policy might prevent harassment by project personnel, prolonged and multiple disturbance of the ten raptor and raven nesting locations near construction activities would be likely during the approximately ten-year construction period.

WATERBIRDS

Loons, grebes, swans, and several species of duck occur on lakes and would not be directly affected by construction activities (Kessel et al., 1982). The major trumpeter swan nesting habitat occurs south and east of the projected impoundment zone and would not be directly impacted. Shorebirds associated with the areas of borrow sites could be affected by loss or disruption of breeding habitat: e.g., harlequin duck, common merganser, semi-palmated plover, arctic tern, and others. Common goldeneye and merganser could lose nesting trees in the borrow areas. Activities in wetlands would also tend to disturb nearby waterbirds, possibly inducing them to avoid the vicinity of construction areas. Overflights could affect lakebirds, inducing avoidance or abandonment of currently used lakes beneath regular flight paths. This could be most pronounced in the Fog Lakes area south of the dam site. However, this area does not support large numbers of waterbirds (Kessel et al., 1982).

The upper and middle Susitna Basin does not provide high-quality habitat for waterbirds and, thus, the basin does not support large numbers of these birds (Figs. K-12 and K-13). Because of

Table K-20. Influence of Timing of Disturbance on the Possible Effects on Raptors

Timing	Possible Effects of Disturbance
Winter	Raptor might abandon nest, roosting cliff, or hunting area (e.g., gyrfalcon)
Arrival and courtship	Migrant raptor might be forced to use alternative nest site (if available); might remain but fail to breed; or, might abandon nest site.
Egg-laying	Partial clutch might be abandoned and remainder (or full clutch) laid at alternative nest; or, breeding effort might cease or site might be abandoned.
Incubation	Eggs might be chilled, overheated, or preyed upon if parents are kept off nest too long; sudden flushing from nest might destroy eggs; or, male might cease incubating; clutch or site might be abandoned.
Nestling phase	Chilling, overheating, or predation of young might occur if adults were kept off nest; sudden flushing of parent might injure or kill nestlings; malnutrition and death might result from missed feedings; premature flying of nestlings from nest might cause injury or death; or, adults might abandon nest or site.
Fledgling phase	Missed feedings might result in malnutrition or death; fledglings might become lost if disturbed during high winds; increased chance of injury due to extra moving about; or, parents might abandon brood or site.
Night	Panic flight might occur, and birds might become lost or suffer injury or death.
General	Undue expense of energy; increased risk of injury to alarmed or defending birds; or, missed hunting opportunities.

Source: Roseneau et al. (1981), Table 12.

this, effects upon waterbirds would be expected to be minor and of no consequence to the integrity of waterbird populations in Southcentral Alaska (Kessel et al., 1982).

OTHER BIRDS AND SMALL MAMMALS

In general, other birds and small mammals would be affected in proportion to the habitat affected by construction activities (Kessel et al., 1982). Habitats affected would amount to less than 1% of the habitat in the basin above Gold Creek. Species most affected would be those associated with forest and shrubland habitats. Much of the habitat not permanently lost to dam facilities would be rehabilitated and some habitat productivity recovered. Revegetation would, at least initially, provide habitat for species characteristic of early plant-community successional stages at the expense of forest inhabitants such as spruce grouse, hairy and downy woodpeckers, alder flycatcher, blackcapped and boreal chickadees, brown creeper, dark-eyed junco, porcupine, snowshoe hare, pygmy shrew, and red squirrel (Kessel et al., 1982). Although large numbers of individuals might be lost, these numbers would represent only a small fraction (<1%) of the estimated population sizes in the basin and surrounding region (Kessel et al., 1982). Thus, construction and filling activities would not pose a threat to survival of local populations of these species. Increased populations of ground squirrel, sea gull, raven, and magpie would be expected in the vicinity of the construction camp and village.

K.3.1.1.2 Operation

MOOSE

After filling of the impoundment, the inundated land would remain unavailable for use as moose habitat (Table K-6). The reservoir would extend for about 54 mi (86 km) upstream to the vicinity of the mouth of the Tyone River, serving as at least a partial barrier to movement. Regulation of flow through the dam site would alter downstream patterns of riverine vegetative succession (see Appendix J) affecting moose dependent upon these riverine habitats. Furthermore, during operation of the Watana development, the reservoir would affect the immediate microclimate of adjacent habitat and result in increased human presence in the interior of the upper and middle Susitna Basin. Loss of habitat is discussed in Section K.3.1.1.1, and increased human access is discussed in Section K.3.1.3.

In addition to the habitat lost to filling the impoundment, fluctuations in reservoir level, permafrost thaw, and erosion would result in further loss of habitat adjacent to the impoundment (Appendix J). This habitat would be predominantly forested. Some areas would revegetate and might provide high-quality forage during early successional stages. The extent to which such loss of habitat might occur has not been quantified.

Presence of the reservoir could alter the quality of habitat used by moose in spring. McKendrick et al. (1982) postulate that the microclimate-moderating effects of the reservoir might delay the emergence of new plant growth (see Appendix J). Such a delay could exacerbate any existing nutritional stress in pregnant cows and newborn calves. Although spring use of the project area by cows with calves is widespread, Ballard et al. (1982a, 1983a) found calving and rearing concentrations in the primary impact zone (within the projected boundaries of the proposed Watana impoundment). Bottomland forest habitat was a preferred habitat type during these observations (Table K-8). During the calving season, 10% to 50% of the approximately 380 observations in the primary impact area occurred below 2,300 ft (700 m) MSL. Thus, it appears that the habitat of the impoundment zone is important to cows with calves.

Ballard et al. (1982a) postulated that pregnant cows move into the bottomland areas in response to early snowmelt and emergence of new plant growth. Moose and other ungulates are frequently in a negative or delicately balanced nutritional state at the end of winter and early spring (Gasaway and Coady, 1974; Moen, 1978; Mautz, 1980; Coady, 1982). New plant growth is probably a necessity for the successful birth and rearing of young, particularly after harsh winters. Delays in the emergence of new growth would have a negative effect upon recruitment of young into the local population.

Loss and alteration of suitable habitat near the impoundment zone would likely compel cows to move to other, possibly less suitable, areas where the competition for suitable browse would increase. Nutritionally stressed cows and calves might also become more susceptible to predators, principally brown bear (Ballard et al., 1981a). Although unquantifiable, the net result of continued operation of the impoundment would be a loss in the recruitment rate of young moose into the local population and possibly a reduction in population size. This effect could be reflected in areas outside of the immediate impact area if there were a net movement of individuals from the middle basin area (Ballard et al., 1982a).

Downstream from the Watana dam site, moose would be affected by alteration of riparian habitat dependent upon the flow dynamics of the Susitna River (Modafferi, 1982, 1983). Island and shoreline habitat are important for both moose overwintering and calving downstream from Devil Canyon (Figs. K-18 and K-19). Effects would be most apparent upstream from Talkeetna. Higher winter flows would be expected to expand the floodplain and displace the zone of early- to mid-successional vegetation (see Appendix J). Smaller islands could be regularly scoured free of vegetation, although the early- to mid-successional zone could be widened on larger islands and the river banks. Above Devil Canyon, the lack of ice scouring and lower summer flows would ultimately lead to a reduction in early- to mid-successional habitat. As noted earlier, habitat in the early- to mid-successional stage (1 to 20 years after disturbance) provides high quality forage for moose (Wolffe and Zasada, 1979). Below Devil Canyon, the quantity of these habitats with high-quality forage could increase or exhibit no net change prior to operation of the Devil Canyon facility (see Appendix J). After Devil Canyon became operational, early-successional stages along the river would likely decrease in the stretch from Talkeetna to Devil Canyon as a result of lowered icing and stabilized flow.

Open water during winter and early spring might serve as a barrier to access to islands. Moose would probably be reluctant to enter the water at this time of year because of the thermal stresses that would be imposed. Thermal energy stress would increase for individuals attempting to swim through open water during this period. As a result of this and loss of some island territory, the availability of suitable calving areas might be reduced downstream from the Watana dam site (Modafferi, 1982, 1983). Islands in the river provide suitable forage for calving and nursing cows and provide security from predators as the islands become isolated from the mainland during river breakup. Loss of access to the islands could negatively affect the success of recruitment of young into moose populations from Watana dam to Talkeetna. Similar affects of lower magnitude would be expected downstream from Talkeetna.

Ballard et al. (1982a, 1983a) have documented major movement patterns of moose that cross or parallel the impoundment zone. A number of moose traditionally follow migration patterns that would be affected by the presence of the reservoir (Fig. K-1). Monitoring of individual moose revealed numerous (>80 observations for 33 moose) instances of moose crossing the river in the vicinity of the proposed impoundment. The presence of an impoundment would likely serve as a barrier to movement at certain times, particularly during winter and early spring. During winter, moose would be reluctant to cross open water downstream from the dam due to the thermal stress that would be incurred. Steep slopes or ice blocks would impose an impediment to movement across the drawdown area during winter and during ice breakup in early spring.

The effects of impeding a moose's movement through its range are not well documented. Moose find suitable habitat on both sides of the river for overwintering, calving, and summer range. Ballard et al. (1982a, 1983a) postulate that restriction of movement across the river reduces the options available to a moose for optimizing the use of suitable range. The home ranges of several moose would be bisected by the Watana impoundment. Restriction of movement would constrain an individual's options to respond to such situations as localized overbrowsing, changes in the mosiac of early successional stages, local variation in browse production, and severe winters.

Several characteristics of the impoundment could pose a hazard to individuals attempting to cross. Ice blocks, frigid waters, mud flats, and unstable ice conditions could pose the danger of mortal or debilitating injury. Difficult crossings could also exacerbate nutritional imbalances due to the strenuousness of the activity. An indirect result of such a situation would be increased susceptibility to predation. Ballard et al. (1982a,d) suggest increased predation by wolves could result. Direct and indirect mortality due to the impoundment would be in addition to the effects of loss and alteration of suitable moose habitat.

CARIBOU

The principal impact to the Nelchina caribou herd would be interruption of movement, chiefly migration, patterns (Table K-9). Although some caribou range will be lost due to the impoundment, the loss amounts to only a small fraction of the available range in the upper and middle Susitna Basin. The projected impoundment area used by a few individuals for summer range (Pitcher, 1982, 1983). This area is considered to be of relatively low quality range.

The Watana impoundment would intersect a historically major migratory pathway, although the route has not been used to a major extent in the past few years (see Sec. K.3.1.1.1). However, even for the current population levels, the upper reaches of the reservoir might serve as partial impediments to caribou migration. This is particularly true for spring migration from wintering grounds to the traditional calving grounds in the upper reaches of Kosina Creek in the Talkeetna Mountains (Fig. K-6). Pitcher (1982, 1983) indicated that many individuals have recently used the impoundment zone as a travel lane during spring migration.

The impoundment would pose impediments to movement of caribou similar in nature to those discussed for moose. Floating ice, unstable ice conditions, open mud flats, snow drifts, and frigid waters could hinder movement and even pose threats of mortal and debilitating injury. Increased susceptibility to predation by wolves and perhaps bear, as well as destabilization of nutritional balance, could be secondary consequences. Crossings during summer and autumn should pose considerably less risk.

Based upon experience at other subarctic reservoirs, the Applicant postulates four possible responses of caribou to the Watana reservoir (Exhibit E, Vol. 6A, Chap. 3, p. E-3-417):

- Caribou would manage to safely cross in the area of Watana and Kosina creeks;
- Caribou would travel farther to the east and cross the Susitna on ice-covered flats near the Tyone and Oshetna rivers;
- Caribou would make hazardous crossings, risking mortality and injury; or,
- Caribou would refuse to cross the impoundment.

The proportion of the herd that would respond in each of these ways is impossible to quantify. The significance of the impoundment as a barrier will be proportional to the numbers of caribou using the area as a pathway from wintering to calving grounds. Currently the majority of the caribou herd winters in the Lake Louise Flats area and females travel to the northern Talkeetna Mountains for calving (Fig. K-7). A number of caribou do use the projected impoundment zone during this migration (Pitcher, 1982, 1983). However, these caribou could probably adjust their movement patterns around the impoundment if necessary because the impoundment would not lie directly between the winter and spring centers of concentration.

Winter use of areas north of Susitna River have historically occurred when herd size was larger than currently (Hemming, 1971; Pitcher, 1982). If herd size increases, the impoundment could become a substantial barrier to movement from north of the Susitna River to the the traditional calving grounds. The impoundment could restrict calving by part of an expanded herd to possibly suboptimal habitats. This could effectively limit the potential for growth of the herd.

Increased disturbance and hunting pressure are discussed in Section K.3.1.3 as they are directly related to access.

DALL'S SHEEP

The principal impact to Dall's sheep due to the Watana development would be inundation of a portion of the Jay Creek mineral lick and increased disturbance and hunting pressure (Table K-9). No other regularly used habitat of Dall's sheep would be affected.

In general, Dall's sheep use areas are removed from the impoundment zone (Fig. K-10). The Watana Hills sheep group does make extensive use of a mineral lick located along Jay Creek (Ballard et al. 1982b; Tankersley, 1983). This mineral lick will be partially inundated by the impoundment. The active lick area ranges from creek level at 2,000 ft (610 m) MSL to the rim at 2,450 ft (740 m) MSL. Maximum reservoir level in October would reach 2,190 ft (670 m) MSL, inundating about 40% of the lick surface area. During the period of maximum sheep use, water level would be about 2,100 ft (640 m) MSL, covering 20% of the lick surface.

Qualitative information from Ballard et al. (1982b) suggests that the lower portion of the lick is more extensively used by sheep than the upper portion.

Annual drawdown is expected to be about 120 ft (40 m), and fluctuations in reservoir level would lead to erosion of the loose soils comprising the lick area. In addition, saturation of lick soils with reservoir water could lead to leaching of soluble minerals from the lick. The more soluble minerals would be most available to the sheep and probably are the more important minerals supplemented in the diet by lick use. These factors, coupled with loss of availability of the lower 20% of the lick during spring, could lead to a marked reduction in the values of the lick to sheep.

The Applicant's recreation plan proposes to provide for recreational use of the Watana reservoir (see Appendix L), including boating opportunities on the reservoir if the second phase of development is adopted (Exhibit E, Vol. 8, Chap. 7, p. E-7-107). Projected maximum annual user days on the reservoir are on the order of several thousand. This recreational use of the reservoir would pose the potential of disturbing sheep using the Jay Creek lick. Sheep are sensitive to human presence (Geist, 1980) and, although recreational use in the spring would be lower than summer and fall, sufficient human activities during May through June could induce sheep to abandon or restrict their use of the lick.

The consequences of reduced availability and abandonment or restricted use of the lick remain uncertain. Many ungulates are known to ingest soil as a source of mineral nutrients, especially sodium (Botkin et al., 1973; Belovsky and Jordan, 1981; Robbins, 1983: pp. 30-60). Terrestrial, non-halophytic plants are generally poor in sodium, and supplements are needed in the ungulate diet. Several other mineral licks have been found in the range of the Watana group, but their relative contribution to the group's nutritional balance is unknown (Tankersley, 1983). The importance of the Jay Creek lick is evidenced by its heavy use even though it is outside of typical sheep habitat and removed from areas of frequent sheep observation. Sheep exhibit a high fidelity to specific mineral licks, and loss of all or part of the Jay Creek lick could have detrimental effects upon the Watana group.

Effects of wave action on the mineral lick might also have a beneficial effect which would partially balance the negative effects. Natural weathering of the exposed lick soils would gradually reduce availability of soluble minerals as they were leached from the surface soil materials. Mineral-rich subsurface soil materials would only become exposed gradually through erosion and occasionally through natural slumping. Action of the reservoir waters would accelerate the rate of exposure of subsurface materials at least for the period of time required for the slopes to reach a new equilibrium with the new conditions. Exposure of mineral-rich materials might make at least part of the lick more valuable to sheep than at present.

The net balance of negative effects of the reservoir upon the value of the mineral lick cannot be quantified. However, it is most likely that the net result would be negative. Minerals in the lower 40% of the lick would be heavily leached by reservoir flooding and would become unavailable to the sheep. Increase in the value of the upper slopes would not likely be sufficient to counter the loss of the lower slope value. Recreational activity in the area would also further reduce the value to sheep of the Jay Creek mineral lick.

BROWN BEAR

Brown bear are highly mobile, ranging over large areas. In the upper and middle Susitna Basin, average sizes of home range are from about 80 to 400 mi^2 (200 to 1,000 km^2) (Miller and McAllister, 1982; Ballard et al., 1982c, Miller, 1983). Bear frequently move across the area of the projected impoundment. Bear move from area to area in response to seasonal variations in availability of vegetable forage, in ungulate concentrations (especially during calving), and in salmon fishing areas. A number of bear cross the area of the projected impoundment to move to salmon spawning grounds along Prairie Creek (Miller, 1983). As for moose and caribou, the presence of the impoundment might impede movements of brown bear. Restriction of bear movement could effectively alter the availability of these seasonal food resources to brown bear. Individual brown bear could lose the flexibility of being able to respond fully to seasonal variability in the location of suitable food supplies. Movement across the reservoir would be particularly difficult in late winter and early spring during ice breakup.

As noted previously, the presence of the reservoir could alter local microclimatic conditions in adjacent habitat, delaying emergence of new plant growth in the spring (McKendrick et al., 1982). The extent of this delay cannot be quantified, but it would reduce the availability of high quality plant food at a time when brown bear are in a state of nutritional imbalance. Brown bear are highly dependent upon spring emergence of food plants in beginning their recovery from overwintering (Craighead and Miller, 1982). In addition, these delays in plant emergence might induce dispersal of spring moose concentrations, another important source of food for post-emergent brown bear.

Downstream populations of brown bear would likely be affected by alteration of salmon spawning sloughs (Miller and McAllister, 1982; Miller, 1983). Alterations in river flow regimes could alter the availability and suitability of sloughs for spawning salmon particularly during reservoir filling (see Appendix I). During the spawning season, brown bear do appear to congregate around these sloughs and take advantage of the abundance of salmon prey (Miller and McAllister, 1982; Miller, 1983). Operational flows might not only lower the abundance of salmon in the sloughs but also lower the suitability of slough morphology for efficient fishing by onshore bear.

During filling of the Watana reservoir, on the order of 10% to 20% of the spawning salmon population above Talkeetna would be expected to be lost (Appendix I). Although the importance of spawning salmon in the diet of brown bear has not been quantified, observations indicate that downstream bear show a marked affinity for riparian areas during salmon spawning season, July-August (Table K-3). During this period about 20% to 25% of the brown bear observations were in riparian areas, suggesting that the bear were responding to the presence of a salmon food source (Miller and McAllister, 1982; Miller, 1983). Preliminary scat analyses support this conclusion. Thus, brown bear might be severely impacted by a reduction in spawning salmon, at least in the short-term.

Long-term effects to the salmon population above Talkeetna are less certain (Appendix I). The population could be severely cut back, to as much as 50% of current levels, which would likely have severe consequences for downstream populations of brown bear. Alternatively, the salmon population might be enhanced by as much as 50% of current levels. This enhancement after filling would help the bear populations recover more rapidly from impacts incurred during reservoir filling. The net result might even be an enhancement of the downstream brown bear populations. The likelihood of either negative or positive extreme has not been quantified.

BLACK BEAR

As with brown bear, climatically induced delays in plant growth, movement restrictions, and a reduction in ungulate prey are likely to further reduce the availability of suitable food for black bear in the upper and middle Susitna Basin. The consequences for the upstream black bear population would likely be more severe than for brown bear. The majority of the suitable habitat for black back in the basin would be in the vicinity of the reservoir (Fig. K-11). Delays in spring emergence of new plant growth would be of greater consequence to the more herbivorous black bear. During spring ice breakup, the reservoir would impede the bear and interfer with their ability to exploit suitable habitat on both sides of the river. The loss of already restricted suitable black bear habitat would be further compounded.

Loss of suitable habitat would be likely to cause black bear to shift activities to more upland locations. Such shifts would increase the probability of interactions with the larger brown bear. Increased interaction could lead to increased mortal or debilitating injury, as well as reduced nutritional status. This situation would further exacerbate the direct effects of impoundment along with effects of increased human activity and hunting pressure.

Effects to downstream black bear would be less than anticipated for the upstream population and similar in nature, though less in magnitude, to effects discussed for downstream brown bear. Reduction in the downstream fishery would have negative impact on the food supply of downstream black bear. There is an indication that black bear do take advantage of the availability of spawning salmon as a food source (Miller and McAllister, 1982; Miller, 1983). Because black bear are less dependent upon animal food, this reduction in salmon availability would not have as great of an impact as anticipated for brown bear.

WOLF

The principal impacts to wolf would be incurred as a result of construction and filling of the reservoir (Table K-13). Operation of the impoundment might increase the susceptibility of some ungulates to wolf, although the net result over the long term would be a reduction of carrying capacity for wolf prey in the vicinity of the impoundment (Ballard et al., 1982d, 1983c). As discussed above, impacts to food supply of the Watana pack could affect recruitment of wolves into more heavily hunted packs.

Other impacts to wolf during operation would be indirect in nature (Table K-13). Effects due to increased human access are discussed in Section K.3.1.3. Loss of area within the territories of the Watana and Jay Creek packs would result in the displacement of wolf activity patterns. Displacement would bring the packs into conflict with wolf in adjacent territories. Interactions among packs would likely result in a subsequent readjustment of territory boundaries and sizes, and possibly the dissolution of one or more packs.

As with other mammals, the impoundment would serve to impede movement and reduce the flexibility of wolf to respond to changes in distribution of prey populations. Countering this lessened flexibility would be restrictions of prey movements imposed by presence of the impoundment.

WOLVERINE

Principal impacts to wolverine would result from loss of habitat due to the impoundment (Table K-14) and increased presence of humans (see Sec. K.3.1.3). Forested habitat near the reservoir might be further reduced by erosion and sloughing along the shoreline, resulting in the loss of small mammal and bird prey. Increased mortality of ungulates around the reservoir during operation might provide carrion to supplement loss of forest habitat. However, these effects would not likely affect the wolverine population as a whole because wolverine are widespread and wide-ranging in the basin.

BELUKHA

It is thought that belukha, or white whale, congregate at the mouth of the Susitna River to feed upon runs of anadromous eulachon and salmon (Exhibit E, Vol. 6A, Chap. 3, p. E-3-434). Eulachon spawn in the lower reaches of the river and are unlikely to be effected by the proposed project (see Appendix I). Salmon appear to be of lesser importance in the diet (Calkins, 1983). If all salmon spawning habitat were lost above Talkeetna, about 5% or more of the currently available salmon would become unavailable to belukha. A reduction in salmon would likely be reflected in a small effect upon the belukha population (Calkins, 1983), however, the natural variability in population sizes would likely mask such effects.

BEAVER AND MUSKRAT

On the whole, downstream beaver would probably benefit from the Watana development, whereas muskrat would be affected detrimentally (Table K-15). No beaver are known to reside in the area of proposed inundation (Gipson et al., 1982). Although a few beaver might use the reservoir, annual drawdown would discourage most beaver from using the reservoir shoreline. Downstream, increased winter flows would be likely to benefit beaver by increasing the depth of ice-free water over current conditions. This enhancement of beaver habitat would be most pronounced upstream from Talkeetna. Some muskrat habitat would be inundated upstream, but a few muskrat downstream might take advantage of additional beaver ponds.

MINK AND OTTER

Impacts from operation would not have further consequence than would result from inundation of habitat (see Sec. K.3.1.1.1).

OTHER FURBEARERS

Impacts to fox and coyotes would be principally due to increased human access (see Sec. K.3.1.2). Some prey habitat would be lost by inundation of about 65 mi^2 (170 km^2) of area (Sec. K.3.1.1.1). Lynx, weasel, and marten would be affected by the inundation of forested habitat by the Watana impoundment. However, impacts are expected to be minor (Table K-17).

RAPTORS AND RAVENS

The major raptors of concern include golden eagle, bald eagle, goshawk, and gyrfalcon (Kessel et al., 1982). The principal impacts to raptors and ravens in the vicinity of the Watana impoundment would be loss or disturbance of nesting locations. About 20 nesting locations would be inundated by the Watana impoundment (Sec. K.3.1.1.1). Impacts associated with human access are discussed in Section K.3.1.3.

WATERBIRDS

Waterbirds are not abundant in the Susitna Basin (Kessel et al., 1982). However, the Watana development would inundate or alter some suitable habitat. Only a small proportion (<0.2%) of lake habitat would be lost. Some species would lose permanent habitat along riverine shoreline and alluvia above Watana dam site. Reservoir filling and fluctuations in reservoir level would eliminate nesting trees for goldeneye and mergansers. All shorebird breeding habitat within the impoundment would be lost.

OTHER BIRDS AND MAMMALS

The major effects to other birds and mammals from the Watana development would be loss and alteration of habitat (Kessel et al., 1982). In particular, wildlife associated with forested habitat would be affected. None of the small bird or mammal taxa are restricted in range to the basin. Thus, although 55 mi^2 (140 km^2) of habitat would be inundated, no taxa would lose more than minor amounts of carrying capacity.

K.3.1.1.3 Threatened or Endangered Species

Federal and state agencies formally list or propose only five taxa as threatened or endangered in the state of Alaska (U.S. Fish and Wildlife Service 1983a; Alaska Dept. of Fish and Game, 1982). Of these taxa, only the endangered American peregrine falcon (*Falco peregrinus anatum*) is likely to occur in the Susitna Basin (Armstrong, 1981; Kessel et al., 1982; U.S. Fish and Wildlife Service, 1983b,c). Although peregrine falcon have been observed in the project area, no nesting locations have been located near proposed project features within the basin. This area is not considered to contain key habitat for the recovery of this species in Alaska (U.S. Fish and Wildlife Service, 1982c). The Watana dam and reservoir would not pose a threat to the continuing survival or recovery of the peregrine falcon in Alaska.

K.3.1.2 Devil Canyon Development

K.3.1.2.1 Construction and Filling

Construction activities at the Devil Canyon development would be similar in nature to those discussed for the Watana development in Section K.3.1.1.1--temporary and permanent loss of wildlife habitat, impedance of wildlife movements, and disturbance of wildlife behavior (Table K-21). Because the Devil Canyon development would not be as extensive as the Watana development, the magnitude of effects to wildlife would be smaller, albeit substantial. Compared with construction and filling of the Watana impoundment, activities at Devil Canyon would affect about 20% additional wildlife habitat (Appendix J). Construction and filling of Devil Canyon reservoir would result in permanent loss of about 7,900 acres (2,800 ha) (App. J, Table J-22) and temporary loss of 1,200 acres (480 ha) of wildlife habitat (App. J, Table J-23). Over 75% of the affected area would be forested. Lesser potential for impact is also attributable to the generally lower habitat quality of the Devil Canyon impact area, principally due to the constricted and rugged nature of the canyon.

MOOSE

The habitat in the vicinity of Devil Canyon supports fewer moose than the habitat above the Watana dam site (Fig. K-2). In part, this is due to the steeper topography of Devil Canyon and the greater extent of mature forest. Because of lower moose densities and smaller area of the impoundment, the Devil Canyon impoundment would affect fewer moose than would the Watana impoundment. Based upon observed ranges of moose between 1976-1982 and aerial surveys and censuses, Ballard et al. (1983a: p. 27) estimated that 450 moose would be affected by the Devil Canyon impoundment compared to 1,800 at the Watana impoundment.

Based upon preliminary estimates of potential winter carrying capacity for moose habitat in the basin (Table K-2), the loss of habitat due to Devil Canyon development would be equivalent to loss of the potential carrying capacity for about 60 moose, in addition to a loss of carrying capacity for 480 moose due to the Watana development. This estimate for Devil Canyon might be low because forage in mature, closed forest was not estimated. However, the more mature forest, which dominates the Devil Canyon area, generally contains 5% to 20% of the available forage found in early successional stages (Wolff and Zasada, 1979). The impacts from Devil Canyon then would be substantially less (ca. 10%-25%) than the impacts due to Watana. The Devil Canyon area does contain areas of moose concentration during winter and spring (Figs. K-3 and K-5). However, development of Devil Canyon would further extend the impacts during these important periods and, added to the effects of the Watana development, would result in a further reduction of the moose population recruitment rate and size.

Effects of moose disturbance from construction activities at Devil Canyon would be in addition to those incurred during construction of Watana. The area of disturbance would shift downstream from Watana. The area of maximum disturbance [noise levels in excess of 60 dB(A)] would extend about 0.3 mi (0.5 km) from the edge of construction activities, encompassing less than 3 mi^2 (8 km^2). Based upon moose densities in the dam area (ca. 1.1/mi^2, Fig. K-2), only about three moose would likely be affected by direct disturbance. This is considerably less than the number calculated for the Watana construction areas.

Table K-21. Potential Impacts to Wildlife from Devil Canyon Development

Species	Project Features	Impacts
MOOSE		
		Permanent Habitat Loss:
	Impoundment area and permanent facilities	Wintering habitat loss would reduce carrying capacity the equivalent of about 60 moose.
		Spring habitat loss would be minor but might displace a small number of moose that calve in this area.
		Habitat Alteration:
	Reclaimed areas	Borrow area K and the temporary camp and village would contain winter browse for equivalent of about 2 moose.
	Hydrologic-induced alteration	Increased water temperatures and open water in winter would occur downstream as far as Talkeetna, otherwise impacts would be as described for Watana.
		Barriers, Impediments, and Hazards to Movement:
	Impoundment	Impacts would be as for Watana, but less severe.
	Downstream	As for Watana, except open water might occur as far downstream as Talkeetna.
CARIBOU		
		Permanent Habitat Loss:
	Impoundment area and village and airstrip	An inconsequential proportion of total range would be affected.
BROWN BEAR		
		Permanent Habitat Loss:
	Impoundment	Some spring feeding areas would be lost.
		Prey population reduction might affect brown bears.
		Disturbance:
		As for Watana.

Table K-21. Continued

Species	Project Features	Impacts
BLACK BEAR		
		Permanent Habitat Loss:
	Impoundment area	Loss of spruce forest habitats.
		Loss of 6% of known black bear dens in impoundment area.
		Disturbance:
		As for Watana.
WOLF		
		Disturbance Related to Construction Activities:
		As for Watana.
FURBEARERS		
		Permanent Habitat Loss:
	Impoundment	Would be less severe than for Watana, but similar in nature.
		Beaver might successfully colonize this impoundment due to small annual drawdown, particularly during wet years.
		Disturbance Related to Construction Activities:
	Impoundment clearing	Would temporarily displace fox.
		Would likely eliminate mink and otter from affected areas.
		Might disturb daily activities and force abandonment of aquatic habitats where they occur near construction zones.
	Other sites	As for Watana.
RAPTORS AND RAVEN		
		Permanent Habitat Loss:
	Impoundment	Would lose 2 of 16 (12%) golden eagle nesting locations.
		1 of 3 known goshawk nesting locations would be lost.
		4 or 5 of 21 (19%) previously used raven nesting locations would be lost.

Table K-21. Continued

Species	Project Features	Impacts
RAPTORS AND RAVEN (continued)		Habitat Alteration:
	Impoundment clearing	Tree nesting locations for small raptors and owls would be lost.
		1 goshawk nesting location would be lost.
	Borrow sites and reclaimed areas	1 gyrfalcon nest might be located in borrow site K.
		Disturbance Related to Construction Activities:
	Impoundment clearing	5 golden eagle nests would be susceptible to disturbance.
		1 gyrfalcon nest would be susceptible.
		6 raven nests would be susceptible.
	Dam construction	1 golden eagle nest would be susceptible.
		1 raven nest would be susceptible.
	Borrow sites	1 gyrfalcon nest would be susceptible in borrow site K.

CARIBOU

Caribou are characteristic of open tundra and shrubland habitats (Miller, 1982), which comprise less than 5% of the habitat that would be affected by the Devil Canyon development (App. J, Tables J-22 and J-23). Although a few individuals might be affected, the overall impacts would be minute.

DALL'S SHEEP

The habitat for Dall's sheep in the region is well removed [about 25 mi (40 km)] from the Devil Canyon development area (Fig. K-9). The project features are well below elevations at which Dall's sheep regularly are found [2,000 ft to 3,500 ft (600 to 1,000 m)]. The Devil Canyon development would add no further impacts to those incurred during Watana development.

BROWN BEAR

The principal impact to brown bear would be loss of 5,900 acres (2,400 ha) of spring forage (App. J, Table J-22). The lowland forest habitat provides an mportant source of early plant growth and overwintered berries. These foods are probably important for recovery of nutritional balance after brown bear emerge from the den. The more mature forests of the Devil Canyon areas would probably provide less spring food than found in the younger forests associated with habitat upstream of the Watana dam site. Thus, losses due to the Devil Canyon development would not be as great as for the Watana development, although the Devil Canyon effects would be added to the effects of Watana development.

Brown bear might avoid the area of the construction activities due to noise and the presence of humans. This would effectively amount to a loss of this habitat for the duration of construction (ca. ten years). Based on the average population density in the basin, the 3-mi^2 (8-km^2) area of direct disturbance would be expected to contain no more than one brown bear (Miller and Ballard, 1982). Thus, disturbance effects would be expected to be minor.

The presence of garbage in the camp might prove to be an attraction for brown bear. This and the presence of humans would increase the likelihood of human/bear interactions. Bears might become nuisances and disruptive of human activities. As a result, some bear might be killed. Proper control of wastes would ensure that such instances would be few.

BLACK BEAR

As occurs upstream from the proposed Watana dam site, black bear in Devil Canyon principally use the lowland, spruce forest habitat (Miller and McAllister, 1982). This habitat type comprises about one-third of the forest habitat that would be lost due to the Devil Canyon impoundment. About 1,900 acres (760 ha) of spruce forest (App. J, Table J-22) would be covered by the Devil Canyon impoundment. This is the principal area of black bear use in the vicinity of the project (Fig. K-11). Based upon the estimated density of black bear in the impoundment area, about five bears would be affected by reservoir filling (Miller and McAllister, 1982).

As with the Watana impoundment, black bear dens might be inundated by filling of the Devil Canyon impoundment. Of the 18 dens known to occur along Devil Canyon, only one would be flooded by filling of the proposed reservoir (Miller, 1983). Above the proposed Watana site, 13 of 24 known dens would be flooded. Thus, the impacts of Devil Canyon filling would be less, although additional to, the impacts from filling of the Watana reservoir.

Black bear would be subject to disturbance during construction of the Devil Canyon dam. On the average, about three black bear might be expected to occupy the zone of direct disturbance. Thus, only a small fraction of the black bear population would be directly disturbed. A few nuisance bears might disrupt activities in the construction camp and village.

WOLF

Filling of Devil Canyon reservoir would remove an additional 7,900 acres (2,800 ha) from the territory of the Watana wolf pack (Fig. K-12). This would amount to only about 2% of the total territory, but with Watana development, a total of 10% of the territory would be lost to the Watana pack (Ballard et al., 1983c). This loss would have a serious effect upon this pack because the inundation area would represent about 45% of the observed wolf use.

FURBEARERS

Impoundment effects upon aquatic furbearers would be small due to the lack of suitable habitat in Devil Canyon. About ten beaver might be affected by development of the construction camp and borrow area (Gipson et al., 1982). Loss of mature spruce and mixed forest would impact chiefly pine marten, which are dependent upon such habitat. Gipson et al. (1982) estimated that about 55 marten might be affected by filling Devil Canyon reservoir. Fox, marten, and weasel might be attracted to the construction camp and village, becoming nuisance animals.

RAPTORS AND RAVENS

A total of nine or ten additional raptor and raven nesting locations would be susceptible to Devil Canyon construction and filling activities (Table K-22). One gyrfalcon nest could be lost to excavation of borrow site K (Fig. 2-6); one golden eagle and one raven location are susceptible to excessive disturbance. Filling of Devil Canyon would affect an additional seven or eight raptor and raven nesting locations which would be inundated by the reservoir. As at the upstream Watana site, golden eagle losses would be of greatest concern. Kessell et al. (1982) estimated that about 17 mi (27 km) of good-quality raptor cliff-nesting habitat would be inundated, leaving about 15 mi (25 km) above waterline. However, although there is abundant cliff habitat in Devil Canyon, it is little used by cliff-nesting raptors and ravens. Kessel et al. (1982) speculate that the high, turbulent winds in the canyon make the area undesirable to raptors. A shallower, broader, canyon after filling might reduce the violence of the winds sufficiently to make the canyon more suitable to cliff-nesting raptors.

Table K-22. Raptor and Raven Nesting Locations Likely to Be Affected by Construction Activities at Devil Canyon

	Number of Locations	Effects
Golden eagle	3-4	1 within 0.6 mi of dam construction; 2-3 in inundation zone
Bald eagle	0	
Gyrfalcon	1	May be removed by quarry excavation
Goshawk	1	Within inundation zone
Raven	4	1 within 0.4 mi of dam construction; 3 within inundation zone
Total	9-10	

Conversion: To convert miles to kilometers, multiply by 1.61.

Source: Exhibit E, Vol. 6A, Chap. 3, Table E.3.161.

WATERBIRDS

Most waterfowl would not be affected by the Devil Canyon development. As with the Watana development, reservoir filling would flood nesting habitat for such riverine shore birds as spotted sandpiper, wandering tattler, dipper and others.

OTHER BIRDS AND MAMMALS

About 9,100 acres (3,700 ha) of habitat would be affected by construction and filling of the Devil Canyon reservoir (App. J, Tables J-22 and J-23). About 75% of the affected habitat would be forested. For species of birds and mammals dependent upon forest, habitat would be lost for thousands of individuals (Kessel et al., 1982). Affected forest-nesting birds would include woodpeckers, black-capped chickadee, Swainson's thrush, yellow-rumped warbler, and others. Red squirrel, porcupine, and snowshoe hare are mammals generally restricted to forest habitat. Although thousands of individual animals would be affected, all of these species are widespread throughout Southcentral Alaska. Thus, impacts of Devil Canyon filling would result in only minor reductions in the sizes of regional populations of these species.

K.3.1.2.2 <u>Operation</u>

During operation, principal impacts would be associated with altered microclimate, altered downstream flows, impeded movement, and continued loss of habitat. Flow regimes below Devil Canyon would be expected to remain as discussed in Section K.3.1.1.2 for the Watana development. The location of riparian habitat might shift, and the abundance of early- and mid-successional vegetation would probably be reduced (App. J, Sec. J.2.1.2.2). However, increased water temperatures would result in open water to Talkeetna during the winter. Habitat alteration due to lack of ice staging, ice deposition on vegetation, and microclimate changes might occur along the open water (Appendix J).

K.3.1.3 Access Routes

K.3.1.3.1 Denali Highway-to-Watana Route

NON-HUNTING MORTALITY

It is anticipated that there could be substantial direct mortality of moose and caribou along the access route. Large volumes of traffic would be expected during the peak construction years--on the order of 500 to 600 vehicle-trips per day, or 20,000 to 25,000 vehicle-miles per day from Denali Highway to Watana (Exhibit E, Vol. 6b, Chap. 3, Table E.3.167). During winter, vehicle collisions are more likely because the open roadway provides an attractive route for ungulate passage, and the berms of snow on either side restrict escape movements. Citing data from the Alaska Department of Fish and Game, Commonwealth Associates (1982) note that up to 300 moose have been killed along the 360-mi (580-km) Alaska Railroad during a single winter. During this period trains passed along at the rate of approximately 90 to 180 train-miles (145 to 290 km) per day. Thus, the potential for collision of ungulates and vehicles would be high along the proposed access route from Denali Highway.

This access route passes principally through upland shrubland and tundra habitats (Fig. 2-11 and Appendix J). These habitats support relatively low densities of moose, about to $1/mi^2$ ($0.4/km^2$) (Fig. K-2). This density is lower than generally occurs along the Alaska Railroad (Modafferi, 1982, 1982).

No major moose movements are known to cross the route of the proposed access road (Fig. K-1). However, the road would pass through the major migratory path for the Nelchina-Upper Susitna subherd of caribou. Thus, impacts to caribou from vehicle collisions would be more likely than impacts to moose.

HABITAT LOSS AND ALTERATION

Some wildlife habitat would be lost due to construction of the roadway and excavation of associated borrow pits (App. J, Table J-26). In addition, some habitat adjacent to the right-of-way would be altered because of changed drainage patterns. These impacts would be minor, amounting to only about 0.02% of the habitat available in the basin. One currently active bald eagle nest would be destroyed by construction of the access road as originally proposed (Exhibit E, Vol. 6A, Chap. 3, p. E-3-489). In its mitigation plan, the Applicant proposes to reroute the road around this nesting location (Exhibit E, Vol. 6B, Chap. 3, Fig. E.3.8.1). The road would pass through the best potential habitat for bald eagle nesting along Deadman Creek (Fig. 2-11).

Approximately 65 beaver occupy upper Deadman Creek, along which the road would extend. Over 40 beaver could be negatively impacted by excavation of borrow areas and construction of the road (Exhibit E, Vol. 6A, Chap. 3, p. E.3.487; Gipson et al., 1982). The road would likely degrade beaver habitat in some instances and enhance it in others. Effects would be principally due to changes in drainage, sedimentation, and bank destabilization. The Applicant projects the net result would be negative.

DISTURBANCE

A principal impact of both construction and operation of the access road would be disturbance of wildlife using habitat adjacent to the right-of-way. The effects of such disturbance include disruption of behavioral patterns and nutritional budgets, avoidance of habitat around the right-of-way, and reluctance to pass through areas of extensive human activity. The secondary consequences of disturbance due to increased human access to the interior of the Susitna Basin are discussed below.

Disturbance due to traffic is likely to be extensive during the peak construction period for Watana dam. During this period, 500 to 600 vehicles per day would pass along the Denali Highway and the access road to Watana (Exhibit E, Vol. 6B, Chap. 3, Table E.3.167). This is an average of one car passing a given point in either direction on the road about every 2.5 minutes, although there would be peak periods during shift changes when traffic density would be considerably higher.

There have been a few studies of the responses of wildlife to traffic and roads. There is some evidence that passing vehicles may elicit alert or startle responses from wildlife within 0.1 to 0.5 mi (0.2 to 0.8 km) of a roadway (Singer, 1978; Rost and Bailey, 1979; McArthur et al., 1982). Traffic has also been documented to deter animals from road crossings (Singer, 1978). Inhibition of movement across the roadway would effectively isolate individual animals from parts of their historical range. Under conditions of low traffic flow and if hunting pressure were low, wildlife might habituate to traffic activity and access road presence (Shultz and Bailey, 1978; Rost and Bailey, 1979; Tracy, 1977; Singer 1978). However, during dam construction, the access road would be heavily used. Additionally, the road might also be used as a staging point for hunting forays if public access were allowed.

Although all wildlife along the access route might be disturbed by highway activities, the effects to the Nelchina caribou herd would be of greatest concern. The access road would bisect the range of the Upper Susitna-Nenana subherd which ranges from Coal Creek to the Parks Highway, south of the Nenana River. Pitcher (1983) estimated that 35% to 50% of the subherd moves westward into the Chulitna Mountains for summer and returns to the area east of the proposed access road in the fall. Presence of the road could affect the success with which the subherd can utilize its current summer range. If the main herd should return to wintering north of the Susitna River, the access road could also influence seasonal movement into higher quality range from the main herd as well.

There have been several studies of the relations of caribou and roadways (e.g., Cameron et al., 1979; Cameron and Whitten, 1980; Jakimchuk, 1980; Fancy, 1983). Some have found that caribou avoid areas of human activity including roads, and exhibit a reluctance to cross them. Fancy (1983) concluded that these responses were inconsequential, amounting to only 10% to 20% of his observations. In contrast, cow-calf pairs tended to avoid habitat adjoining the Trans-Alaska Pipeline haulroad (Cameron et al., 1979; Cameron and Whitten, 1979). Cows with calves appear to be most sensitive to the presence of roads and human activity (Jakimchuk, 1980). Although caribou herds do coexist within road networks (Jakimchuk 1980), it is unlikely that these roads carry traffic at the levels that would be expected for the Watana access road during the peak construction period.

Because the access road would extend between the spring/winter and summer ranges for 35% to 50% of the Susitna-Nenana subherd, it is likely that it would affect cow-calf groupings. This would have implications for the success of recruitment of young into the subherd and hence for the maintenance of the subherd size. Quantification of these potential affects is not possible with the current data base.

Presence of the access road might also lead to the disturbance of brown bear, especially in denning areas. Brown bear have been observed at greater numbers away from the Denali Park Road than along the road (Tracy, 1977). Miller and Ballard (1982b) reported evidence of short-term reluctance of brown bear to cross highways during long-range homing movements of transplanted individuals. Avoidance of the road would lead to a decrease in availability of some forage along the route. It is likely that the brown bear would avoid denning areas near the proposed route (Exhibit E, Vol. 6A, Chap. 3, p. E-3-484). In addition, winter construction might cause abandonment of nearby dens and subsequent mortality.

The access route would pass near [<0.5 mi (0.8 km)] four red fox den complexes (Exhibit E, Vol. 6B, Chap. 3, Figs. E.3.80 to 81). It would be likely that the heavy use of the access road would make these sites unusable. Tracy (1977) observed several fox dens within 330 ft (100 m) of the Denali Park road. However, such habituation to the access road would be less likely due to heavy usage of the road during construction and increased trapping pressure if the road were open to the public.

No raptor cliff-nesting and only one tree-nesting site is located along the proposed access route. If the route were located to avoid the one bald eagle nest location, the site would still be subject to disturbance from traffic activity. The Applicant proposes to shift the route 0.5 mi (0.8 km) west of the nesting location. This would reduce the effects of traffic but would still allow ready human access to the site.

INCREASED HUMAN ACCESS

Currently, the Susitna project area is accessible only to a limited number of people (see Appendices F and L). The Watana site is located approximately 40 mi (60 km) south of the nearest highway, the Denali Highway (Fig. 2-11). Access to the region is primarily by airplane, although all-terrain vehicles can access parts of the area and boats can float down the Susitna River to Vee Canyon from the Denali Highway and up the river to Devil Canyon. By allowing access for personal vehicles, the access road to Watana would open up the middle Susitna Basin to a considerably larger population than now accesses the basin.

The Susitna project would affect patterns of human access by providing an access road and by directly increasing the numbers of people in the basin. During construction of dams, use of the access road would be limited (to the extent possible) to project personnel and other authorized persons. For the 20-year period of construction, approximately 2,000 persons would be regularly accessing the basin. Presence of the temporary and permanent villages would bring about 1,500 and 200 persons into the center of the basin, respectively. Post-construction use of the access road could be opened to the public, and, thus, it could serve as a conduit for recreational users of the basin. Post-construction recreational use of the basin is expected to be around 30,000 user-days per year beyond the projected baseline levels (Exhibit E, Vol. 8, Chap. 7, Table E.7.13). The Applicant estimates that consumptive uses would double and nonconsumptive uses quadruple as a result of the project.

Increased human presence in the basin would have two principal impacts: increased potential for disturbance of wildlife and increased hunting pressure. The effects of disturbance to wildlife are described in previous discussions. Increased human presence in the basin would exacerbate these effects. Areas of high human use would be avoided by more sensitive wildlife such as sheep and brown bear. Increased disturbance could cause population ranges to shift from higher to lower quality habitats effectively reducing basinwide carrying capacity. Although wildlife populations do successfully coexist with human users of lands elsewhere in Alaska, these populations are generally smaller than in areas where humans are present less frequently.

Hunting is a major recreational activity in Southcentral Alaska (see Appendix L). A major factor limiting the distribution of hunting in the Susitna basin is accessibility. Thus, hunting pressure is more intense on the periphery of the basin where the highways provide ready, inexpensive access. The proposed access road to Watana would provide this type of access to the interior of the basin. Hunting pressure would likely increase for wildlife populations that previously were not hunted intensively. Increased hunting pressure would chiefly affect those populations for which hunting is not regulated by permit. In Game Management Unit 13, only caribou, sheep, and some moose hunting is regulated by permit (Alaska Dept. of Fish and Game, 1983a). Hunting of other game species is regulated by bag limit and age/size/gender limits. For example, bull moose with at least a 36-inch (91-cm) spread in antlers or three brow tynes on at least one antler, can be taken at a rate of one moose per season. Other moose may be taken by those holding one of a limited number (150 in 1983-1988) of permits for subsistence uses only.

Increased hunting pressure in the central part of the basin could lead to increased mortality and lowered population sizes. This could affect more peripheral populations, because for several species the interior populations may supply recruits to more heavily hunted peripheral populations. Wolf populations might be particularly affected because there is no limit on take of wolf during hunting seasons (Alaska Dept. of Fish and Game, 1983b).

Improved access to the project area might also increase trapping pressure on furbearers in the basin. Current trapping intensity is low, but inexpensive and ready access might induce trappers to increase activities in the basin. Currently, trapping is regulated by bag limit (Alaska Dept. of Fish and Game, 1983b). Fox, beaver, and marten could be affected substantially by extensive trapping in the basin.

Regulation of hunting and trapping in the Susitna Basin is the responsibility of the Alaska Department of Fish and Game (1983a,b). Limits on take are set in order to maintain population size of wildlife at specific levels in keeping with management goals. If increased hunting and trapping pressure depressed populations below these levels, the department would likely take steps to further limit take in the basin. This would not directly affect illegal take, but poaching would likely be included in the decision-making process of setting new limits. If proper regulation were implemented, as it has in the past, the effects upon wildlife of increased hunting pressure should be ameliorated.

PATTERNS OF HUMAN USE

Development of recreational facilities in the project area would dramatically increase the numbers of persons using the basin for nonconsumptive uses. With no access or facilities, nonconsumptive users would be rare. Easier access and less rustic conditions would likely entice nonconsumptive users into the basin, particularly as demand for recreational facilities in surrounding areas increases. Increased human usage would result in some disturbance effects upon local wildlife, particularly in the vicinity of developed facilities.

Consumptive uses in the basin would be expected to increase up to twofold as a result of the project. Wildlife populations in the basin interior would be subject to higher harvest pressure and increased take. In combination with increased mortality and decreased productivity due to other project impacts, increased harvesting would likely result in wildlife populations stabilizing a lower, perhaps much lower, sizes than currently exist.

The makeup of the basin's user population would probably also change. The average per user-day dollar value would probably decline in the basin because of the presence of a less expensive access alternative and an influx of use types that carry lower dollar values. The proportion of high dollar value out-of-state users would likely decline whereas in-state user proportion would likely increase. The absolute number of out-of-state users might also decline in the basin because these users might not wish to pay high value for the hunting/wilderness experience in an area of higher user competition and more human development.

The development of the area would markedly alter the quality of experience for users in the basin. The consequences of altering that character depend upon individual user tastes. Compared to conditions in the absence of the project, post-project users would probably encounter more human activity, suffer a lower take per effort or success rate, and perhaps view fewer game. For many users, these conditions would lower the quality of the hunting/wilderness experience.

Thus, users would be more likely to be those who prefer not to expend large sums of money to use areas of lower human development and possibly higher harvest success rate.

Subsistence users would be the group most severely impacted. Decreased wildlife productivity and increased competition for the harvest would result in decreased success rates. Decreased success rates would be detrimental to the extent that further effort could not be expended to maintain an absolute rate of take per season and to the extent the user was dependent upon subsistence for his or her own well-being. Unfortunately, this cannot be quantified at this time.

Human use and wildlife management policy and strategy for the upper and middle Susitna Basin would likely need to be reviewed and revised in order to meet goals for wildlife conservation, subsistence maintenance, and other uses.

K.3.1.3.2 Watana-to-Devil Canyon Route

This access road would have impacts of the same nature as the route between Denali Highway and the Watana site. Additional, but a smaller amount, of habitat would be lost or altered (App. J, Table J-26). Human access would become more readily extended to the Devil Canyon site (Fig. 2-11), with concomitant extension of effects to wildlife from disturbance, disruption of movements, and increased hunting.

Because fewer individuals use this area, the impacts to moose and caribou would be less than expected for the access route to Watana. However, the route between Watana and Devil Canyon would cross prime brown bear habitat. The route would pass several fox denning complexes that might be impacted. A golden eagle nest location and a raven nest location are within 0.3 mi (0.4 km) of the proposed route. The bridge would be about 0.5 mi (0.8 km) downstream from a golden eagle nest location. Activity along the road might make these locations unsuitable for nesting.

K.3.1.3.3 Devil Canyon-to-Gold Creek Rail Access

Effects from the rail access route to Devil Canyon would generally parallel those described previously. Access would be more limited because vehicle traffic would not use this access route. Rail access is more amenable to limiting the number of users. The rail route would pass within 0.3 mi (0.5 km) of a bald eagle nest located across the Susitna River. Construction and operation could make this site at least temporarily unsuitable.

This route might increase access to the Stephan Lake and Prairie Creek area, south of the Devil Canyon site (Fig. 2-11). The presence of the construction camp at Devil Canyon would certainly increase the numbers of people visiting the Prairie Creek area. This area is a major congregating point for brown bear during salmon spawning (Miller and Ballard, 1982b; Miller, 1983). A large number of bear from some distance [30 mi (50 km)] travel to Prairie Creek, suggesting that it is an important feeding area for the regional brown bear population. Increased disturbance from human presence could result in a reluctance of bear to use the area, effectively denying them a high-quality food source. This could lead to a reduction in the size of the regional population of brown bear.

K.3.1.4 Power Transmission Facilities

K.3.1.4.1 Dams-to-Gold Creek Segment

CONSTRUCTION

Effects of construction of the proposed transmission lines and substations would fall into two categories: (1) loss and alteration of habitat with consequent loss or alteration of wildlife carrying capacities, and (2) disturbance of individual animals due to noise generation and human activity. Between the dams and Gold Creek, approximately 510 acres (200 ha) of forest would have to be cleared (App. J, Table J-28). This amounts to about 30% of the right-of-way; most of the forested land occurs in the 8 mi (13 km) from Devil Canyon to Gold Creek (Fig. 2-14).

Many studies have examined the impacts of clear-cutting and right-of-way management on wildlife (e.g., Arner, 1977; Asplundh Environmental Services, 1977; Carvell and Johnston, 1978; Galvin and Cupit, 1979). In general, right-of-way clearing would result in the presence of wildlife who prefer open habitat with few large trees. These wildlife species would be those characteristic of early stages of plant community succession, such as are found in abandoned farm fields or areas of post-fire regeneration. Maintenance of a clear-cut strip in an area of extensive forests would offer a more diverse habitat than pure forest stands, supporting a greater diversity of wildlife (Mayer, 1976; Johnson et al., 1979; Geibert, 1980; Cavanaugh et al., 1981; Kroodsma, 1982). The herbaceous and shrubby growth would also provide food for a number of wildlife species (Krefting and Hansen, 1969; Kufeld, 1977; Cavanaugh et al., 1981). Rights-of-way have been assessed as having high value for use by wildlife, particularly where they cross extensive woodlands (Mayer, 1976; Asplundh Environmental Services, 1977; Bramble and Byrnes, 1979; Eaton and Gates, 1981).

The two big game species that most likely would be affected are moose and black bear. Moose are moderately abundant below the Watana dam site and use lowland forest during winter and spring (Figs. K-2 through K-4). Moose make use of early successional habitat as a major source of forage (Peek et al., 1976; Peek, 1974; La Resch et al., 1974; Coady, 1982). Clear-cutting has been shown to enhance the availability of high-quality forage for moose in both winter and spring (Telford, 1978; Brusnyk and Gilbert, 1983). Interspersion of clear-cut areas with forest enhances forage availability while retaining needed winter cover. Clearing of the forest for the right-of-way would likely enhance the local availability of forage. Wolff and Zasada (1979) have estimated that early successional stages (1 to 15 years after disturbance) can provide 5 to 20 times the available moose forage found in older forest. Enhanced forage availability along the right-of-way could compensate for a fraction (10%-40%) of the expected loss of winter carrying capacity due to the impoundments (Tables K-6 and K-22). However, Wolff and Zasada (1979) found that actual use in disturbed areas ranged from 0 to 50% of estimated carrying capacity and averaged only about 20%. Thus, although increased acreage of high-quality forage might be available along the right-of-way, moose might not take advantage of it.

Black bear make extensive use of the lowland spruce forests along the Susitna River. During the spring, post-emergent black bear rely heavily on new plant growth to recovery nutritional balance after overwintering. Early successional stages of plant communities are important sources of spring plant forage for black bear, and the clear-cut right-of-way would provide a source of high-quality forage (Lindzey and Meslow, 1977; Pelton, 1982). However, as with moose, black bear might not use the rights-of-way.

Creation of segments of early successional plant communities in forested habitat would also allow enhancement of populations of small mammals and birds characteristic of open habitat and ecotonal habitat at the expense of species characteristic of forested habitat. For example, arctic ground squirrel, tundra vole, and meadow vole populations are likely to expand into the cleared right-of-way (Kessel et al., 1982). Red squirrel, marten, and other forest species would be negatively affected by the clearing of the right-of-way.

The proposed lines to Gold Creek pass through moose overwintering areas (Fig. K-5). During winter, the openness of a cleared right-of-way would result in more extreme temperatures, greater winds and convective heat loss, and greater amounts of drifting snow than found in forested habitat (Herrington and Heisler, 1973). Lower temperatures and higher winds would impose greater thermoregulatory stresses on moose occupying the right-of-way. Deeper snowdrifts would increase the metabolic costs of travel and would cover potentially important sources of winter browse. Thus, even though the right-of-way might contain high-quality forage, heavy snow might limit winter use of the clearing by moose. Several studies have shown that deer avoid open rights-of-way in the winter in direct proportion to the width of the clearing (Hydro-Quebec, 1981; Doucet et al., 1981; Willey, 1982). Moreover, the movement of moose has been shown to be restricted by deep snow (Coady, 1974, 1982; Telfer, 1978). The proposed broad rights-of-way [e.g., 300 to 510 ft (90 to 150 m)] could result in restrictions of moose movement during winters of heavy snow, limiting the accessibility of suitable forage for overwintering moose.

Although the primary impacts to wildlife would result from alteration of habitat in the right-of-way, there are several other potential impacts that could result from the construction of the transmission line. The principal such impact would be disturbance of local wildlife. Raptors and waterbirds are particularly sensitive to human disturbance (Stalmaster and Newman, 1978; Swensen, 1979; Erwin, 1980; Liddle and Scorgie, 1980; Burger, 1981). One golden eagle, and two raven nesting locations are known to be within 1 mi (1.6 km) of the proposed right-of-way (Kessel et al., 1982). Although these would be susceptible to impacts from transmission line construction, it is likely that nearby Devil Canyon dam and access route construction would already have impacted these locations. In addition, a bald eagle nesting location occurs within 0.3 mi (0.5 km) of the proposed route near the mouth of the Indian River, and a goshawk (historical) and a gyrfalcon location are within 1 mi (1.6 km) of the proposed route, east of the proposed Devil Canyon site (Kessel et al., 1982). Approximately four black bear dens occur within 1 mi (1.6 km) of the route near the Watana damsite. During line construction these sites might be affected and wildlife discouraged from using them. On the whole, disturbance impacts would be expected to be similar to those from construction of the access routes from Watana to Gold Creek which approximately parallel the proposed transmission line route.

OPERATION

During operation, the right-of-way through forest would be maintained in an early successional stage, retaining impacts of forest clearing throughout the life of the facility. In addition to the presence and maintenance of a cleared right-of-way in forest habitat, there would be other potential impacts during operation. These would include collisions of birds with towers or conductors, electrocution, ozone generation, audible noise generation, and electric/magnetic field effects (see Appendix D).

There are several documented cases of bird mortality from collision with conductors or tower structures (Avery et al., 1978; U.S. Fish and Wildlife Service, 1978). The majority of the species involved in such incidents are migratory waterfowl. The proposed transmission line would not be tall enough [ca. 100 ft (30 m)] to pose a threat to any birds in migratory flight. In general, migratory flight occurs at altitudes in excess of 100 m (300 ft) above ground surface (U.S. Fish and Wildlife Service, 1978; Lincoln, 1979). However, waterfowl landing or taking flight could strike components of a line passing over or immediately adjacent to an open body of water. The proposed line would pass within 2,500 ft (760 m) of several small lakes and would cross several drainages and wetlands that might be used by waterfowl, particularly near Devil Canyon and near Gold Creek. Because this represents only a minute fraction of the available habitat of this type, it is unlikely that the threat of collisions would affect more than a minor fraction of waterfowl in the locale. In addition, as noted earlier, a large waterfowl population is not found in this area (Kessel et al., 1982). In general, collisions with power lines do comprise a small fraction (<1%) of non-hunting mortality (Stout and Cornwell, 1976; Banks, 1979).

Electrocution could occur when an animal makes contact with two energized conductors or with one energized conductor and a shield wire or grounded part of the support tower. Historically, this has been a problem with large raptors (such as eagles) and small lines (Benson, 1982). The cliffs along the river provide excellent nesting habitat for golden eagle (Kessel et al., 1982). It is likely that raptors could use transmission structures for hunting perches. However, minimum clearances on the proposed 345-kilovolt (kV) line [>10 ft (3 m)] would ensure that there was no possibility of electrocution. The Applicant also would design the 34-kV line from Cantwell to Watana in such a way that raptor electrocution would be unlikely (Exhibit E, Vol. 6A, Chap. 3, p. E-3-539). Perceptible spark discharges from wildlife to ground under the line are also unlikely because wildlife are normally well grounded.

Operation of lines operating at greater than 345 kV is known to generate ozone when the lines are in corona (Electric Power Research Inst., 1982). Maximum short-term concentrations of ozone at ground level have been measured at about 20-40 micrograms per cubic meter ($\mu g/m^3$), or 10-20 parts per billion (ppb), above background levels during foul weather at voltages in excess of 1,000 kV. This is about 40% of the level of detectability and 10% of the minimum concentration required for toxic effects during short-term exposure of animals (Cleland and Kingsbury, 1977; Goldsmith and Friberg, 1977; Coffin and Stokinger, 1977). Therefore, it is unlikely that the transmission line would generate sufficient ozone to be detrimental to wildlife in the vicinity of the line.

During foul weather, audible noise levels could approach a 24-hr, day-night weighted average of 60 dB(A) beneath operating lines (Electric Power Research Institute, 1982). Wilderness background noise ranges from 20 to 30 dB(A), depending upon weather conditions; therefore noise could be audible above background (U.S. Environmental Protection Agency, 1974b). There are insufficient data to quantitatively relate audible noise emissions to impacts to wildlife along the right-of-way. Deer and elk have been observed using transmission line rights-of-way despite the presence of audible noise (Lee and Griffith, 1978). Wildlife use of transmission line rights-of-way under a variety of weather conditions implies that audible noise has a negligible impact upon wildlife activities. Thus, it appears that the low level of audible noise emitted by the proposed transmission line would be unlikely to deter wildlife from using habitat within or in the vicinity of the right-of-way. However, Klein (1971) cites evidence that suggests caribou might be reluctant to cross the right-of-way beneath operating transmission lines.

Magnetic fields from the proposed line would not be expected to influence animals in the vicinity of the line because field strength dissipates rapidly with distance from the line, and field levels would be well below (by about a factor of 10^{-5}) levels known to elicit even equivocal responses in laboratory animals (Bracken, 1979).

Maximum electric field under 345-kV AC lines could be expected to be about 5 kilovolts per meter (kV/m) (Electric Power Research Inst., 1982). Biological responses to fields of 5 kV/m or less have been observed only after several days of continuous exposure. No deleterious effects have been reported for fields this low. Because of the animals' mobility, such conditions would be improbable for free-ranging animals using the right-of-way under the proposed line. In addition, maximum field strengths would only be found immediately under the conductors and would dissipate rapidly with distance. Beyond the edge of the right-of-way, field strengths would be below levels known to elicit responses.

K.3.1.4.2 Healy-to-Willow Segment

The Healy-to-Willow of the Susitna power transmission system would occupy a right-of-way covering about 4,600 acres (1,500 ha) for a distance of about 170 mi (270 km) adjacent to the existing Anchorage-Fairbanks transmission intertie (Fig. 2-7). The line would cross a diversity of habitat ranging from open tundra (ca. 15% of the right-of-way) to closed forest (ca. 50% of the right-of-way) (App. J, Table J-30). Approximately 2,300 acres (920 ha) of forest would need to be cleared along this portion of the transmission line.

As with the dams to Gold Creek segment, the principal impact of construction of the line would be alteration of forest habitat into early-successional, herbaceous/shrub habitat. Moose would be the most common big game species affected (Commonwealth Assoc., 1982). Modafferi (1982) estimated moose densities of 3.5 to 10 per mi^2 (1 to 4 per km^2) in the Susitna River drainage below Gold Creek. Moose numbers decline to the north. Clearing would likely enhance moose forage, although moose might not extensively browse in these areas (Wolff and Zasada, 1979). South of Gold Creek, moose move across the proposed route of the transmission line to winter and spring concentration areas along the Susitna and other major waterways (Figs. K-18 and K-19). The right-of-way would be likely to form a barrier to movement during winters when deep snow collected in clearings through forested habitat (see Coady, 1974, 1982). During these winters, high-quality forage in the right-of-way would probably be inaccessible.

Caribou are not abundant along this segment of the proposed transmission line, chiefly due to the paucity of tundra habitat (Commonwealth Assoc., 1982). Because clearing of tundra habitat would not be necessary, little caribou habitat would be altered along the right-of-way. Caribou might avoid some suitable habitat during the construction period.

Brown and black bear might also avoid the right-of-way in response to the noise and human activity. The activities during winter construction might also induce bear to abandon dens that might be located near the right-of-way. After construction, the cleared right-of-way would provide high-quality forage characteristic of early-successional stages.

The proposed transmission line would not extend through the habitat of the Dall's sheep population in the high country between Healy and Cantwell. However, use of helicopters during construction and maintenance could cause sheep to avoid habitat near the right-of-way (Commonwealth Assoc., 1982). Sheep can be quite sensitive to human presence and activity (Geist, 1980). Impacts to sheep would be most pronounced if presence of the Susitna transmission system required substantially more maintenance activity, especially overflights, than would be required for the existing Intertie alone.

Some beaver might be adversely impacted where clearing was required near occupied drainages. Clearing of mature spruce forest would adversely affect marten, although marten do exploit some open habitats (Strickland et al., 1982). In general, other furbearers and small mammals would be adversely affected to the extent that they are dependent upon forest habitat that would require clearing and maintenance in an open state.

Clearing of trees would result in some loss of potential nesting locations for bald eagle, particularly south of Gold Creek. Three bald eagle nesting location are known to occur within 1 mi (1.6 km) of the proposed route (Commonwealth Assoc., 1982). Although these nests would be avoided by the right-of-way, they still could be susceptible to disturbance. Golden eagle nesting habitat north of Cantwell could also be affected by disturbance from construction and maintenance activities. Cleared portions of the right-of-way might provide additional foraging area and hunting perches for raptors that hunt in open habitat.

Waterbirds, such as ducks, swans, and shorebirds, are more common in the southern portions of the proposed route, north of Willow (Commonwealth Assoc., 1982). Collisions with conductors and support structures would be likely but would not contribute substantially (0.5%-0.6%) to mortality (Stout and Cornwell, 1976; Avery et al., 1978; U.S. Fish and Wildlife Service, 1978; Banks, 1979). Localized mortality could be higher.

Trumpeter swans establish nests in the area in May and remain until August (Commonwealth Assoc., 1982). Two trumpeter swan nests are located along the route, north of Willow. Hansen et al. (1971) noted that during nesting and rearing stages, trumpeter swans are very sensitive to human disturbance. Construction and maintenance activities during the summer could disrupt nesting and rearing of trumpeter swans located near the transmission line route. Impacts from the Susitna line might not increase disturbance substantially above levels that would be incurred due to the existing Intertie.

Increased human accessibility along the transmission line from Healy to Willow should not pose a major threat for wildlife. The route would parallel the Parks Highway and Alaska Railroad through much of its length. The presence of the Intertie would also have provided existing access for human use of the area. The additional access opportunities that would result from the proposed line would be minor.

K.3.1.4.3 Healy-to-Fairbanks Segment

The 100-mi (160-km) Healy-to-Fairbanks segment of the Susitna transmission line would traverse about 3,500 acres (1,400 ha) of right-of-way (Fig. 2-15). About 70%, or 2,600 acres (1,000 ha), of the route would pass through forested habitat (App. J, Table J-32). Shrubland and tundra habitats would comprise about 15% and 10%, respectively, of the right-of-way. Thus, the principal impact from this segment of the line would be loss of forest habitat and maintenance of open, early-successional plant communities in a 300-ft (90-m) strip through forested areas.

Moose and black bear are the principal big game species along the proposed route from Healy (Selkregg, 1977; Alaska Dept. of Fish and Game, 1973, 1978). Maintenance of the cleared right-of-way could provide high-quality browse for moose (Wolff and Zasada, 1979), as well as for black bear. Moose densities along the proposed route range from 0.2 to 1/mi^2 (0.06 to 0.4/km^2) (Gasaway et al., 1983). Moose were more abundant along the southern portions of the segment; however, most forest clearing would occur north of Nenana (Appendix J). Thus, moose may not take advantage of the increased availability of forage in the right-of-way.

North of Nenana, black bear would predominate, while in the more open habitat north of Healy brown bear are more common. Winter construction activities could disturb denning bear adjacent to the right-of-way. If bear abandon dens, this could lead to increased mortality of some bear due to the relative paucity of suitable food during winter. No dens are known within 1 mi (1.6 km) of the proposed route, although intensive surveys have not been carried out.

Caribou winter in the open habitats north of Healy (Selkregg, 1977). Because minimal clearing would be required in non-forested habitat, little caribou habitat would be lost in right-of-way preparation. Construction and maintenance activities might cause caribou to avoid the right-of-way, at least when humans were present. Additionally, caribou might be reluctant to use the right-of-way during operation of the line, principally because of the noise that would be generated (Klein, 1971). However, it is unlikely that the right-of-way would impose a major barrier to caribou movement.

The transmission line would pass an area of low waterfowl densities as it parallels the Nenana River between Healy and Nenana (Selkregg, 1977). North of Nenana the forested habitat along the proposed right-of-way is unsuitable for waterfowl. Between Healy and Nenana, six trumpeter swan nesting areas are known to occur within 2 mi (3.2 km) of the proposed route (Acres American, 1982b). These nests could be subject to disruption during summer construction and maintenance along the right-of-way (Hansen et al., 1971).

North of Nenana, the proposed route passes within 1 to 5 mi (2 to 8 km) of a number of peregrine falcon historical nesting locations (U.S. Fish and Wildlife Service, 1983c; Alaska Power Authority, 1984). Although these locations have not been used recently, in the past peregrine have occupied these sites during the summer season. The proposed route would not pass through any peregrine nesting location, nor would it pass through high-quality habitat. However, the route would pass within 1 to 5 mi (2 to 8 km) of habitat highly suited for peregrine nesting along the northern side of the Nenana River (Alaska Power Authority, 1982). Potentially, noise and human activity along the right-of-way during nesting season could discourage peregrines from using these locations in the future (U.S. Fish and Wildlife Service, 1983c). To preclude this, steps would be taken to avoid disturbing activities during the nesting season if peregrines were present.

Because the transmission line route would roughly parallel the routes of the existing Parks Highway, Alaska Railroad, and Healy-to-Fairbanks powerline, it is unlikely that the proposed right-of-way would increase access into areas not currently accessible. Thus, the problems of increased access would be unlikely to occur in this area.

K.3.1.4.4 Willow-to-Anchorage Segment

South from Willow, the proposed transmission line would traverse about 30 mi (50 km) of right-of-way covering 2,000 acres (810 ha) of wildlife habitat (Fig. 2-14). About 65%, or 1,300 acres (530 ha), of the right-of-way would be forested (App. J, Table J-34). About 25% of the right-of-way would extend through wet sedge-grass wetlands. The habitat is typical of the lower Susitna drainage basin, with extensive forested wetlands as well as herbaceous wetlands.

Moose range extensively through the area (Figs. K-17 to K-19). Modaferri (1982, 1983) estimated winter moose densities of about 10 per mi^2 (4 per km^2) along the lower end of the Susitna River. Dispersal eastward from the area of winter concentration would bring moose to the right-of-way. The cleared right-of-way would have higher levels of browse available than nearby forest, and moose might use the right-of-way for this reason (Wolff and Zasada, 1979). Black bear could also make use of the early-successional vegetation in the cleared right-of-way.

The wetlands south of Willow provide habitat for a large number of waterfowl (Selkregg, 1974; Sellers, 1979; U.S. Dept. of Agriculture, 1981). The proposed line would pass west of the Nancy Lake State Recreation Area and northeast of the Susitna Flats State Game Refuge. The Susitna Flats Refuge has the highest waterfowl harvest rate of the three refuges in the subbasin below Willow (U.S. Dept. of Agriculture, 1981). Collisions of waterfowl and the transmission line are most likely along the segment south of Willow. Even here, however, mortality rates would be only a small fraction of the mortality due to other causes (Stout and Cornwell, 1976; Banks, 1979).

Clearing of the right-of-way would undoubtedly remove some nesting habitat for the bald eagle. However, the clearing of 910 acres (360 ha) of forest represents only about 0.2% of the forest in the basin south of the Kashwitna River (U.S. Dept. of Agriculture, 1981). Thus, the line would have little effect upon bald eagle nesting in this area.

South of Willow the proposed right-of-way would diverge from the principal access routes of the region. The right-of-way could increase the accessibility of the area to ground vehicles. This could result in increased hunting pressures upon waterfowl in the Susitna Flats area. Management and harvest plans of the Alaska Department of Fish and Game might have to be altered to account for this increase in hunting pressure.

K.3.2 Susitna Development Alternatives

K.3.2.1 Alternative Dam Locations and Designs

Use of alternative designs for the dams and related facilities would result in essentially the same impacts to wildlife as discussed above for the proposed project (Sec. K.3.1). This is principally because the major impacts would be due to impoundment filling and continuing presence of a reservoir. The chief impacts of alternative designs would result from human presence and activity and permanent or temporary loss of habitat. Relocation of some ancillary facilities might alter the type of habitat affected, and alteration in facility size would change the quantity of habitat affected. However, these changes would not likely cause only significant alteration of the magnitude of the total affected habitat because dams, spillways, and ancillary facilities comprise less than 5% of the area that would be impacted by construction of the dams.

Relocation of facilities might alter the pattern of human disturbance in the project area. However, the change would not be substantial because facilities could not be moved a great distance from their proposed location without reducing their utility to the project. Thus, disturbance impacts would be at the same level as discussed previously.

Construction of the Watana I alternative would lower the maximum reservoir elevation behind the Watana dam to about 2,100 ft (640 m) MSL. Hence, the area of inundation would be reduced to about 28,300 acres (11,400 ha) (Wakefield, 1983) of which about 85% would be expected to be vegetated habitat. The quantities of each habitat type that would be lost would be proportionate to those that would be expected to be lost for the proposed dam. However, lowland forests would likely from a larger proportion of the lost habitat because of the lower elevation of maximum inundation.

Impacts of a Watana I alternative would be similar to those described in Section K.3.1.1; however, the magnitude of inundation would be reduced about 20%. The same wildlife populations as discussed previously would be impacted. Moose and black bear would be the principal wildlife species affected by a Watana I alternative. Estimated winter carrying capacity for the equivalent of approximately 400 moose would be lost to inundation behind a Watana I configuration. On the order of 6% of the suitable habitat for black bear and 40% of the known dens could be lost to a Watana I development. The Jay Creek mineral lick would still be inundated, but a larger proportion of the lick would be available for sheep than under the proposed plan. The Watana wolf pack would still be affected by loss of the central portion of its home range. One less bald eagle nesting location would be flooded under the Watana I configuration than under the proposed. Impacts to wildlife movement would be reduced from the proposed project because of the 4 to 5 mi (6 to 8 km) reduction in reservoir length under the Watana I configuration.

Because the smaller Watana I dam would require less volume of fill material, this alternative would require less extensive use of the borrow areas than the proposed project. Thus, temporary habitat loss would be reduced. Impacts to some wildlife using the borrow areas might be avoided by implementation of this alternative. The shorter construction period for the smaller dam would also reduce the duration of disturbing human activity in comparison to the proposed Watana development.

Downstream impacts of implementing the Watana I alternative would be similar to those discussed previously (Sec. K.3.1). Alteration of flow regimes would alter successional patterns of riverine vegetation, and ice-free waters could prevent access to moose calving habitat on river islands. Impacts to the bear fishery and potential enhancement of beaver habitat would also result from alteration of the downstream flow regime. The magnitude of these impacts would be directly dependent upon the degree to which flow patterns were altered from natural conditions. This alteration might be less under the Watana I alternative than under the proposed plan.

Implementation of either a Modified High Devil Canyon alternative or a Reregulating dam alternative in lieu of the Devil Canyon proposal would affect the same wildlife populations discussed in Section K.3.1.2. Because the impoundments would be smaller for the alternatives, less habitat would be lost than would be expected for the proposed Devil Canyon development. Approximately 15% or 55% less habitat would be inundated through implementation of the Modified High Devil

Canyon or Reregulating dam alternatives, respectively. The resulting impacts to wildlife would be reduced accordingly.

K.3.2.2 Alternative Access Routes

Differences in habitat that would be affected by alternative access routes would not be substantial. All alternatives and the proposed access would affect much less than 1% of the basinwide habitat. Principal differences would involve human access to the central portions of the basin.

Access from the Parks Highway to Devil Canyon would cross a stretch of wetlands habitat between the highway and Indian River. This habitat supports moose, black bear, and beaver. Construction of this route could necessitate cuts through slopes adjacent to wetlands, with subsequent erosion impacts to wetlands resources. The brown bear fisheries of Portage Creek and Indian River could also be affected by erosion from the right-of-way.

Access from the Parks Highway would provide a major route of access into the central portion of the upper and middle Susitna Basin (Fig. 2-13). As discussed previously, this increased access would impact both the wildlife resources and the current human users of the basin. The Parks Highway is the major link for personal vehicles between the population centers of Alaska. Thus, a direct linkage to the highway would provide ready access to the basin by personal ground vehicles. Patterns and intensity of human use would likely be altered. Greater use of interior regions would result, impacting previously unused or slightly used wildlife populations. The magnitude of use would increase substantially.

The southern access route from Devil Canyon to Watana would cross extensive wetlands in the area from Stephan Lake to Fog Lakes (Fig. 2-13). This area supports moderate densities of moose as well as other wildlife. The principal impact of this alternative would be improved surface access to Stephan Lake and Prairie Creek. Prairie Creek supports the most interior salmon run within the basin. From 30 to 40 brown bear congregate in the area during July and August to exploit this fishery (Miller and McAllister, 1982; Miller, 1983). The importance of this fishery to brown bear cannot be quantified. However, the fact that some bear travel in excess of 30 mi (50 km) suggests that this fishery is important to the regional brown bear population. Increased access to the area would increase human/bear interactions. As a result, bear might begin to avoid the area in response to increased hunting pressure, harassment, or disturbing human presence.

K.3.2.3 Alternative Power Transmission Routes

Selection of alternative transmission line routes (Figs. 2-14 to 2-16) would variably affect wildlife relative to the proposed routes, depending upon length of line, amount of clearing of forest habitat required (App. J, Tables J-38 to J-41), proximity to raptor or swan nesting locations, and amount of waterfowl habitat traversed. Qualitative impacts would be the same as discussed previously. The amount and distribution of impacts would vary among alternatives.

The alternative transmission lines would have essentially similar impacts to the proposed lines (see Sec. K.3.2.3). Impacts would chiefly be a result of clearing forested habitat for the right-of-way. Differences among the alternatives are in the amount of right-of-way clearing required. Most of the routes encompass approximately the same areas. Routes from Watana to the Healy-Willow Intertie that extend northward would generally cross twice the area crossed by routes extending westward. Routes extending southeast of Nenana across the Tanana Flats also would occupy twice the area of routes passing nearer to Nenana. Routes around Knik Arm would also cross more acreage than routes extending from Willow to Anchorage across MacKenzie Point.

The routes from the dam sites to the Railbelt are fundamentally similar except in length. Several are twice or more the length of the proposed route and would be expected to have greater impact to wildlife habitats. Routes passing from Fog Lakes to Stephan Lake could have substantially higher potential for waterfowl collisions, although such mortality would still be a small fraction of overall mortality. Routes passing through the uplands north of the Susitna River could impact brown bear denning habitat. Selection of any transmission line route not associated with a selected transportation access route would further enhance accessibility of the region. The proposed route would traverse the shortest length of habitat among the alternatives and follows the proposed access route from Gold Creek.

Alternatives for the Healy-to-Fairbanks segment are basically similar except in length. Only alternatives that swing south of the Tanana River and extend to the southern side of Fairbanks would avoid the prime peregrine falcon habitat located along the northern side of the river from Nenana to Chena Ridge. Impacts to the potential peregrine habitat could be avoided by proper scheduling of construction and maintenance activities. Therefore, the extra mileage required to avoid the area would not be warranted.

From Willow to Anchorage, the principal difference among alternatives would be the length of the route. Alternative routes around Knik Arm would be nearly twice the length of routes to Pt. MacKenzie. No particular advantages would be gained by selecting the longer alternatives.

K.3.2.4 Alternative Borrow Areas

Alternative use of borrow areas (Figs. 2-2 and 2-6) would result in temporary loss of habitat in the areas actually used, except where the borrow areas would be inundated by the reservoir. No major reductions in impacts to wildlife would be achieved by selecting one area over another except by using areas that would be inundated or affected by construction anyway, such as areas A, B, D, E, I, J, L, and G. Borrow areas C and F would likely have additional impact on browse habitat for moose and other wildlife over and above reservoir filling, although the areas could be rehabilitated to regain at least a portion of the browse productivity. Borrow areas H and K are situated in more rugged, cliff habitat that would be suitable raptor nesting areas.

K.3.3 Non-Susitna Generating Alternatives

K.3.3.1 Natural-Gas-Fired Generation Scenario

The two combined-cycle units situated along the Beluga River (Fig. 2-18) would occupy about 10 acres (4 ha) of upland spruce-hardwood forest. Because such gas-fired units produce no solid wastes, this area would be comprised of onsite facilities only. This acreage would be effectively lost from use as wildlife habitat. Moose congregating in the area during winter might be disturbed by human activities during construction and operation. Responses of moose and other wildlife have been discussed previously (Sec. K.3.1). Moose might tend to avoid the plant area, but this would affect only a minute fraction of their winter range. Along the Chuitna River (Fig. 2-18), the three combined-cycle units would occupy about 15 acres (6 ha) of upland spruce-hardwood habitat. Plant construction and operation might disrupt black bear denning areas along the Chuitna River. However, the plant area represents less than 1% of the available habitat. Some areas used for fishing by brown bear during salmon spawning might also be impacted. Brown bear denning area would be located in upland sites, removed from this alternative site. No other areas of known wildlife sensitivity would be affected by the alternative plant. The area is already accessible by road, and alternative developments would not substantially increase accessibility. Access would undoubtedly be upgraded to some extent, but ongoing logging and fossil fuel development currently affect local wildlife, and any additional impacts would only be incremental.

Near Kenai (Fig. 2-18), two combined-cycle units would occupy about 10 acres (4 ha) of lowland spruce-hardwood habitat. Although a variety of wildlife range through the area, no known sensitive areas exist in the vicinity of these possible alternative developments. The affected habitat would be a small fraction (<<1%) of available range. The area is developed with roads, and petroleum industry activity is extensive. Thus, the alternative developments would not materially increase human presence.

The 15 acres (6 ha) devoted to thermal plants in the Anchorage area (Fig. 2-18) would be situated in more urbanized habitat and would not substantively affect wildlife resources in the region.

The natural-gas-fired facilities would not contribute substantively to local air pollution problems (Appendix G). Thus, impacts to wildlife via air pollutants would not be expected.

Some new transmission line right-of-way would be required to connect the generating capacity to existing power systems. Impacts would be similar to those already discussed (Sec. K.3.1). The lines would be relatively short because these alternatives would be located in developed areas. The magnitude of impacts would be proportional to the length of transmission line required.

K.3.3.2 Coal-Fired Generation Scenario

The 400 MW of coal power generation that would be installed near Willow (Fig. 2-18) under this scenario would require approximately 400 acres (160 ha) of area for plant facilities and waste storage. Principally lowland spruce-hardwood habitat would be impacted. The plant would be located in an area of high densities of moose and black bear. However, suitable habitat occurs throughout this portion of the Susitna Basin. The area is lightly developed for recreational purposes, and access might be enhanced to some degree by this development. This development could also result in increased disturbance to nesting trumpeter swans and bald eagles.

The three Nenana coal units (Fig. 2-18) would be located mainly in bottomland spruce-hardwood habitat and require about 500 acres (200 ha). Moose do concentrate in the area during winter, but the plant facilities would occupy only a small fraction of the habitat available. Some trumpeter swan nesting might be disturbed. Historical peregrine nesting locations would potentially be within 5 mi (8 km) of the plant. Because the area is located on the Parks Highway, no additional accessibility would result.

Coal mining near Healy (Fig. 1-14) would necessitate disturbing about 3,000 acres (1,200 ha) of upland spruce-hardwood and tundra habitat. Brown bear, caribou, and moose would be most impacted by this habitat loss. Reclamation of the mined land could recover some of the lost productivity. Big game mortality along the Alaska Railroad could increase dramatically, particularly during winter when coal shipments could require two to three times the current rail traffic.

Localized alteration or damage of wildlife habitat might result from fugitive dusting near the mine pit, along transportation routes, near coal storage piles at the plant and the mine or at transportation loading facilities, and near waste disposal sites (Dvorak et al., 1978). Specific effects would be dependent upon site-specific parameters, such as wind conditions, plant community type, chemical composition of the dust, and the magnitude of dust-control efforts. Trace elements in runoff or seepage from solid-waste disposal areas might have some localized effects on vegetation surrounding the site (Soholt et al., 1980). However, the chances of adverse effects would probably be low because the waste would be dry rather than a slurry. In addition, liners could be employed if site-specific evaluations indicated they would be necessary to reduce seepage to groundwater and adjacent soils.

Considering the high particulate removal efficiency (99.95%) assumed for the coal units, no impacts to wildlife habitat from trace element combustion emissions would be expected (see Appendix J). On the basis of dispersion modeling of combustion emissions (App. G, Sec. G.2.3), SO_2-sensitive plant species would not likely suffer acute injury or damage even under worst-case fumigation conditions. Even for three 200-MW units, the maximum annual 3-hr average SO_2 concentrations at ground level under worst-case fumigation conditions would occur 0.8 mi (1.3 km) from the plant and would be less than 75 $\mu g/m^3$. This concentration is well below the acute injury threshold level for even the most sensitive plant species (Dvorak et al., 1978).

Although the potential for SO_2-induced chronic or long-term injury or alteration of plant communities would exist near the coal units, it is impossible to predict whether such effects would actually occur. This is because little information on chronic or long-term injury threshold level exists in the literature.

It is unlikely that wildlife habitat in the vicinity of the coal units would be directly affected by NO_x emissions. For three 200-MW units, the maximum annual 3-hr average NO_x concentrations at ground level under worst-case fumigation conditions would be approximately 220 $\mu g/m^3$, which is well below the acute and chronic threshold injury levels (about 2,000 $\mu g/m^3$) for plants (Dvorak et al., 1978). However, NO_x emissions could contribute to the formation of secondary pollutants such as ozone or peroxyacetyl nitrate (PAN) through reactions with airborne hydrocarbons, and NO_x together with SO_2 and ozone might cause greater injury than any one of the pollutants would alone (Dvorak et al., 1978).

In general, animal species are less sensitive to gaseous pollutants than the more sensitive plant species (Dvorak et al., 1978). Anticipated ground-level concentrations of SO_2 and NO_x would be expected to be several orders of magnitude below threshold levels for direct effects upon wildlife species. Thus, wildlife species would be unlikely to be affected by aerial emissions from coal combustion.

Use of up to 50 acres (20 ha) required for combustion-turbine units would have effects similar to those described in the previous section, but the exact nature of impacts would depend upon precisely where the units were located. It is likely that these plants would be located near the population centers of Anchorage, Palmer, and Kenai.

K.3.3.3 Combined Hydro-Thermal Generation Scenario

Implementation of the combined hydro-thermal alternative would result in inundation of over 115,000 acres (46,000 ha) of habitat ranging from tundra to forest (Table K-23). Nearly 85% of this habitat would be a result of development of the reservoir at the Johnson site (Fig. 2-18). The Keetna development would eliminate the salmon runs to Prairie Creek. As discussed previously, loss of this fishery could have a severe impact to brown bear and bald eagle in the upper and middle Susitna Basin. The Chakachamna development could affect brown bear fisheries downstream. Winter range for caribou and moose would be affected by the Browne and Johnson developments. Mountain goat and Dall's sheep might be disturbed by construction activities at the Snow development. Both species are relatively sensitive to human presence. Increased accessibility would likely occur at the Keetna, Snow, and Chakachamna sites. The Brown and Johnson sites would be situated along major highways. Other impacts would be similar in nature to those described for the Susitna development. Impacts from thermal developments would be as described in the preceeding section. The magnitude of impacts would vary with size of the development, value of wildlife habitat affected, and numbers of wildlife affected.

K.3.4 Comparison of Alternatives

Differences among alternative borrow areas are only substantive for those areas that would not be inundated by reservoir filling, areas C, F, H, and K (Figs. 2-2 and 2-6). Alternative transmission line routes are all longer than the proposed routes, and few cross more sensitive wildlife habitat. The access alternative with least impacts to wildlife would be rail/road access from Gold Creek to Watana, south of the Susitna below Devil Canyon and north of the Susitna above Devil Canyon. This route would avoid the sensitive Stephan Lake area, avoid passing across the movement pathway of the Nenana-Upper Susitna caribou, and maintain more restricted access than is proposed.

Table K-23. Relative Potential for Impacts to Wildlife from Alternative Generation Scenarios

Scenario	Habitat Loss (acres)	Moose	Caribou	Brown Bear	Black Bear	Furbearers	Raptors	Waterbirds	Human Use
Susitna Hydroelectric Project	64,000	High	Moderate-High	Moderate	High	Low	Moderate	Low	High
Watana I-Devil Canyon	55,000	High	Moderate-High	Moderate	High	Low	Moderate	Low	High
Watana I-Modified High Devil Canyon	54,000	High	Moderate-High	Moderate	High	Low	Moderate	Low	High
Watana I-Reregulating Dam	52,000	High	Moderate-High	Moderate	High	Low	Moderate	Low	High
Natural-Gas Generation	9,000	Low	None	Low	Low	Low	Low	Low	Low
Coal Generation	12,000	Low-Moderate	Low	Low	Low	Low	Low-Moderate	Moderate	Low
Combined Hydro-Thermal without Chakachamna	115,000	Moderate	Low	High	Low	No	No	Low	Low-Moderate
Combined Hydro-Thermal with Chakachamna	116,000	Moderate	Low	High	Low	No	No	Low	Low-Moderate

Conversion: To convert acres to hectares, multiply by 0.405.

Alternative power generation configurations would differ substantively in impacts (Table K-23). On the basis of amount of habitat lost, the combined hydro-thermal alternative would be the least desirable for wildlife considerations; this alternative would affect twice the amount of habitat affected by the proposed project. However, the value of the affected habitat might be lower for the combined configuration; although the Keetna development would eliminate the fisheries of the Prairie Creek area which are used by brown bear.

The thermal alternatives would affect fewer wildlife resources than would any of the hydropower alternatives to the proposed project. Natural-gas configurations would affect more than six times fewer acres of wildlife habitat. Coal-fired configurations would affect more than five times less acreage than hydropower developments. For the most part, these alternatives would be developed in habitats of low sensitivity or affect only a small fraction of sensitive habitat. Additionally, thermal developments would generally occur in areas with some degree of existing human development.

The natural-gas configuration would be most compatible with wildlife conservation goals because far less land is required.

K.4 MITIGATIVE ACTIONS

The Applicant has proposed a plan to mitigate the effects upon wildlife that might result from the proposed project (Exhibit E, Vol. 6A, Chap. 3, pp. E-3-508 to E-3-550). The Applicant's plan is based upon implementing the following principles in order of their priority:

- Avoidance of impact through project design and operation, or by not taking a given action.
- Minimization of the impact by reducing the degree or magnitude of the action, or by changing its location.
- Rectification of the impact by repairing, rehabilitating, or restoring the affected portion of the environment.
- Reduction or elimination of the impact over time by preservation, monitoring, and maintenance operations during the life of the action.
- Compensation for the impact by providing replacement or substitute resources that would not otherwise be available.

These principles are the key components of mitigation as defined by the Council on Environmental Quality (40 CFR 1508.20), as well as the U.S. Fish and Wildlife Service (1981). The first two principles involve project design measures, and impacts have been discussed incorporating proposed measures into the assessment (Sec. K.3.1). Alternative design measures that might further avoid or reduce the magnitude of impacts are discussed in Sections K.3.2 to K.3.4. The succeeding discussion emphasizes the last three principles.

K.4.1 Proposed Mitigation

The Applicant has identified the principal impacts to wildlife and developed preliminary plans for mitigating these impacts to the extent possible given the Applicant's determination of project needs.

Impoundment clearing activities would not begin until two or three years prior to filling. Patches of riparian vegetation would be left uncleared until just prior to filling. However, this habitat would be permanently lost to inundation of impoundment zones during filling. Delayed clearing would temporarily avoid impacts of habitat loss to marten, moose, and black bear. Avoiding clearing during the winter and early spring would prevent disturbance of moose during overwintering and calving and disturbance of brown and black bear during hibernation. Precise clearing schedules would be determined in consultation with resource agencies.

Revegetation of disturbed sites would reduce the period of temporary habitat loss (see Appendix J). It could provide spring and winter forage for moose for 2 to 20 years after the initiation of reclamation. However, as noted by Wolff and Zasada (1979), moose might not take advantage of this available forage. Bear might be attracted to such sites by the high productivity and early availability of spring forage. However, in some areas, this might increase the frequency of bear/human encounters, with possible negative impacts.

Minimization of habitat loss to the transmission corridor would be accomplished by selective clearing in the corridor, leaving small shrubs and trees, and by leaving a 35-ft (10-m) wide strip of vegetation up to 10 ft (3 m) tall between circuits. Rectification for habitat loss would be provided by allowing vegetation to grow to a height of 10 ft (3 m) during operation. This design could enhance habitat for moose and other wildlife preferring vegetation types in early successional stages. Impacts of habitat loss from other project features might be compensated for through increased carrying capacity for moose provided with this corridor design. Other species (e.g., marten, hare) could also benefit from this corridor design because the retention of cover in the corridor would present less of a psychological or visual barrier to movements.

Habitat alteration that would occur downstream from the Devil Canyon dam would be reduced through the use of multilevel intake structures that would maintain river temperatures as close to normal as possible given operational goals.

Compensation for permanent habitat loss and alteration for moose, brown bear, and black bear would be provided by habitat enhancement measures and acquisition of replacement lands. Carrying capacity for moose and bear could be enhanced by measures which allow development of early successional vegetation, such as burning, logging, or land clearing. These early successional communities generally have higher browse production than mature forest (Wolff and Zasada, 1979). However, as noted previously, wildlife use of this available browse is not a certainty. The Applicant must study further the efficacy of such techniques in order to determine the amounts of compensation that would be required to replace lost carrying capacity.

The Applicant is currently refining its estimates of carrying-capacity losses that might be incurred. As part of this, the Applicant is developing a habitat-based model to determine potential impact of habitat loss on moose populations. An estimate of the number of acres required to mitigate for habitat losses for moose would be determined using this information. The Applicant contends that refinement and use of this model would allow 100% compensation for impacts to moose and development of the modeling approach should also be considered out-of-kind mitigation for species impacts which cannot be otherwise addressed (Exhibit E, Vol. 6A, Chap. 3, p. E-3-530). The Staff feels that current uncertainties do not allow one to reach this conclusion; nor does the Staff consider modeling alone to be suitable mitigation.

The Applicant would assist the Alaska Board of Game in conducting a controlled moose hunt within the project area to avoid over-browsing of the area by displaced moose. The need for such a hunt would be assessed using the modeling approach described above. A hunt would be conducted if studies determine that the receiving areas could not support displaced moose without degradation of carrying capacity and the Board deemed it appropriate.

Hazards to movement created by the impoundment would be reduced through clearing of the impoundment zone prior to flooding and through a program of debris removal as necessary to continue throughout the license period. Monitoring of the impoundment during the open-water period would identify debris hazards.

Sensitive wildlife areas identified in the monitoring studies would be protected from disturbance from project aircraft by the following guidelines and measures for project personnel:

- Pilots would be required to maintain a minimum altitude of 1,000 ft (300 m) above ground level except during take-off and landing throughout the basin.

- Aircraft landings would be prohibited within 0.5 mi (0.8 m) of the Jay Creek mineral lick between April 15 and June 15.

- Aircraft landings would be prohibited within the Nelchina caribou herd calving area in the Talkeetna Mountains between May 15 and June 30.

- Aircraft landings would be prohibited within 0.25 mi (0.4 km) of known active wolf dens or rendezvous sites during May 1 through July 31.

- Aircraft landings would be prohibited within 0.5 mi (0.8 km) of active golden eagle nests between March 15 and August 31.

- Aircraft landings would be prohibited within 0.25 mi (0.4 km) of active gyrfalcon nests between February 15 and August 15.

- An aircraft buffer zone of at least 0.25 mi (0.4 km) or 1,000 vertical feet (300 m) would be established around lakes used by trumpeter swans during the nesting season.

- All aircraft restrictions and schedules would be provided to aircraft pilots in a concise manual.

Ground disturbance of identified sensitive areas would be avoided through the guidelines and measures described below. For the purposes of this discussion, minor ground activity includes short-term reconnaissance and exploration type programs such as field inventories. Major ground activity would involve such things as clearing, pad construction, blasting, and facility construction. All of these would require large numbers of personnel, equipment, surface disturbance, noise, and vehicular activity. The protection measures implemented would include:

- Known raptor nesting locations would be assumed to be occupied until June 1 of each year, after which, protection measures would be withdrawn for the remainder of the year if the nest was documented to be inactive.

- Major ground activity would be prohibited within 0.5 mi (0.8 km) of the Jay Creek mineral lick between April 15 and June 15. The reservoir adjacent to the lick would be closed to boat and floatplane use within 0.5 mi (0.8 km) of the lick.

- Clearing activities in the impoundment area would be restricted to nonsensitive periods near areas identified as sensitive to disturbance (e.g., concentrations of calving moose, brown and black bears, denning wolves, migrating caribou, raptor nests, etc.).

- Major ground activity would be prohibited within 0.25 mi (0.4 km) of all known active bear dens between September 15 and May 15.

- Major ground activity would be prohibited within 0.5 mi (0.8 km) of waterbodies used by swans during the nesting season and other times when swans are present.

- Ground activity would be prohibited within 0.25 mi (0.4 km) of known active wolf dens or rendezvous sites between May 1 and July 31.

- Major ground activity would be prohibited within 0.5 mi (0.8 km) of active golden eagles nests between March 15 and August 31, within 0.25 mi (0.4 km) of active bald eagle nests between March 15 and August 31, or within 0.25 mi (0.4 km) of gyrfalcon nests between February 15 and August 15.

Although complete avoidance of the impacts of altered caribou movements and range use would not be possible with the route proposed, design changes in the access road and realignment to minimize effects on current major use areas of the Nelchina range would reduce its impact. Although this realignment would avoid some areas for caribou calving, some cows that calve in the mountains to the west of the road would still be affected. Use of side-borrow techniques would minimize physical and visual barrier effects of the road to caribou and other species. This technique would result in a finished road profile less than 4 ft (1.2 m) above original ground level and would reduce the amount of habitat lost to material sites.

The effects of vehicle traffic on caribou movements would be minimized by reducing the volume, speed, or frequency of traffic on the road. Public access would be prohibited during the construction period. The Applicant is currently reviewing options for reducing traffic volume. Further minimization of impacts could be provided through busing workers to the site, allowing only convoy traffic, or reducing the speed limit and volume of traffic during sensitive periods. Because dust clouds behind vehicles add to the visual effect on caribou, water trucks would be used to control dust along the road during the construction phase. Continued monitoring would evaluate the residual impact (if any) on caribou and the need for out-of-kind mitigation for caribou.

If monitoring of Dall's sheep indicated a population-level effect of partial inundation of the Jay Creek mineral lick, new soil would be exposed to rectify the impact. Monitoring use and comparison of soil samples would allow evaluation of the effectiveness of this mitigation.

The impact of overharvest of game species with improved access would be avoided during construction by prohibiting public access via the project road or air field, prohibiting employees and their families from using project facilities or equipment for hunting and trapping, and by providing data from monitoring investigations which might assist the Alaska Board of Game in regulating hunting and trapping activities in the area. During the operation phase, the Applicant would have no control over harvest activities but would continue to provide any pertinent data to the Alaska Department of Fish and Game and assistance in their management activities.

The creation of nuisance animals would be avoided through combined implementation of the following garbage-control and education measures:

- An Environmental Briefing Program for employees would be required and would include briefings on regulations prohibiting feeding of animals and reasons for the restrictions.

- State regulations prohibiting feeding of wild animals would be strictly enforced.

- Construction camps and landfills would be fenced with bear-resistant fencing, and gates would be monitored to ensure the effectiveness of the fencing.

- Secure garbage containers would be required in work areas.
- Personnel would be assigned the responsibility for picking up and disposing of all discarded refuse in work areas and along roads.
- Putrescible kitchen wastes would be stored indoors and completely incinerated daily, or more often if required, in adequate incinerators.
- Solid waste landfills would be covered with soil daily, or as required by permit stipulations.

The construction manager would be instructed to develop an animal control strategy directed at avoiding and minimizing all project-related problems and to respond promptly to any situations that arise.

Decreased availability of salmon to bears would be compensated for by enhancement of 13 sloughs between Devil Canyon and the confluence of the Chulitna and Talkeetna rivers (see Appendix I). Increased activity at Prairie Creek could be a secondary impact of the project that would have a negative effect on brown and black bears which make seasonal movements to the area during salmon runs. The Applicant would assist resource management agencies in assessing this impact and in preparing recommendations for mitigating actions.

The impacts of decreased availability of ungulate prey for brown bear, black bear, and wolf would be reduced through measures to avoid, minimize, or compensate for impacts to ungulate populations. However, it is possible that predator populations would be reduced through harvest as a management strategy to allow increased harvest of ungulates by humans. Therefore, complete mitigation of impacts is unlikely for these species.

Loss of habitat for aquatic furbearers would be reduced by lowering gravel requirements through side-borrow techniques and utilizing only borrow sites D, E, I, J, and K (Figs. 2-2 and 2-6). In addition, material for the access road in the Deadman Creek area would be obtained if necessary from small upland sites outside the Deadman Creek drainage.

Loss of habitat for aquatic and semi-aquatic furbearers (especially beaver) would be compensated for through enhancement of sloughs in the reach between Devil Canyon and the confluence with the Chulitna and Talkeetna rivers. Thirteen sloughs in this reach would be managed as salmon spawning sloughs, and beaver are likely to be actively excluded from these. Of the remaining sloughs, the beaver model might indicate the enhancement measures required for colonization and overwintering by beavers. Slough enhancement measures could also benefit muskrat, mink, and otter and might provide complete compensation for aquatic and semi-aquatic furbearers.

The unavoidable loss of raptor nesting locations would be compensated for by site enhancement and the creation of artificial nesting locations. The success of these measures would be determined through annual monitoring efforts. A combination of measures including subsequent modifications would be used until the number of successful new nestings equals or exceeds the number of nesting golden eagle pairs lost to the project.

K.4.2 Recommended Mitigation

As noted above, the Applicant has been developing an extensive mitigation plan for implementation during construction and operation of the proposed project. This plan has been developed in conservation with the major Federal and state resource agencies in Alaska. The formal comments of resource agencies on mitigation have tended to be general critiques of the mitigation plan in its current state. General recommendations include: (1) continued close interaction with the resource agencies; (2) further studies of the effectiveness of proposed actions; and, (3) continued monitoring of the status of wildlife and mitigation actions in the basin.

The Staff concurs that continued, close interaction with the resource agencies is a necessity for developing and implementing mitigative actions. The Applicant also acknowledges the necessity of such interaction. However, there appears to be some dissatisfaction among resource agencies with the current lack of definite direction in the mitigation plan. In large part this is because there is insufficient information as to the feasibility of a number of the Applicant's mitigation proposals.

Many of the mitigation proposals revolve around habitat rehabilitation and enhancement. Many of these proposals are reliant upon limited data and experience. Responses of plant communities to these revegetation and habitat manipulation actions have not been documented sufficiently to predict with confidence the results of implementing these approaches (see Appendix J). The responses of wildlife populations to these manipulations of plant communities are even more difficult to predict with confidence. On the whole, the Applicant has not documented the likelihood of success for its rehabilitation and enhancement proposals nor has the Applicant documented the amount of compensation that could be attributed to the enhancement efforts. For these reasons the Staff has assumed in its analysis that impacts would not be compensated for by enhancement techniques. The Staff concurs that the Applicant should further study the efficacy of proposed rehabilitation and enhancement techniques with the goal of implementing feasible mitigation actions that have a likelihood of success.

Continued monitoring of wildlife populations and their responses to the project and mitigation actions is necessary in order to devise future mitigation or alter the approach to mitigation if needed and to quantify the extent to which mitigation is compensating for losses. The Staff agrees that such studies are an integral part of the mitigation plan.

U.S. Fish and Wildlife Service has stated that several of the wildlife species which it has identified as evaluation species fall within its criteria for requiring "in-kind" compensation. This requires compensation for loss to a given species by replacing or enhancement of the affected species. This approach contrasts with "out-of-kind" mitigation of one species to compensate losses to another species. These differences would have to be resolved during the issues resolution phase of the licensing process.

The State of Alaska has noted that the Applicant cannot rely upon the Alaska Board of Game to mitigate the projects changes in patterns of human use and effects from these changes. The state argues that the Applicant should take every step possible to mitigate impacts prior to any need for the Board of Game to review and revise management strategies. The Staff agrees with this view and considers that any Board review and revisions necessitated by the project would be impacts of the project and not a part of mitigation activities.

Several agencies suggested alterations in proposed project plans in order to reduce or avoid impacts. The Staff has considered these in its discussion of alternatives to proposed project features.

K.5 SIGNIFICANT ENVIRONMENTAL IMPACTS

K.5.1 Proposed Project

As proposed, the Susitna Hydroelectric Project would have severe impacts to wildlife, principally in the upper and middle Susitna Basin. The major project impacts would include:

- Reduction of the Susitna Basin's moose population due to loss of about 60 mi^2 (150 km^2) of important habitat, a twofold increase in hunting pressure, and increased mortality.
- Severe reduction in the basin's black bear population due to loss of about 60 mi^2 (150 km^2) of already-limited habitat from Watana development, loss of 50% of available denning sites, and a twofold increase in hunting pressure.
- Reduction in the basin's brown bear population due to loss of some spring habitat, reduced availability of prey (moose and some salmon), and a twofold increase in hunting pressure.
- Reduction in the basin's gray wolf population due to loss of about 10% of the home range of the central-most pack, reduced availability of prey (moose), and a twofold increase in hunting pressure.
- Possible reduction of the Watana Hills group of Dall's sheep due to reduction in the suitability of the Jay Creek mineral lick as a result of inundation and leaching of soluble minerals.
- Possible restriction of the movement of caribou in the basin.
- Loss or disturbance of 4 bald eagle and 16 to 18 golden eagle nesting locations.
- Loss of 50% of the cliff-nesting habitat along the middle Susitna River.
- Alteration of human-use patterns in the Susitna River Basin due to a fourfold increase in number of users, possibly leading to lowered game-harvest success rates, reduction in the quality of the hunting experience, and a change in the makeup of users of the basin.
- Possible need to alter wildlife management plans and goals within the basin.

K.5.2 Alternatives to the Proposed Project

Significant environmental impacts from implementation of alternatives to the proposed project would include:

- Some alternative transmission routes would double the amount of habitat crossed in comparison to the proposed routes.

- Elimination of the Denali-Watana access route would markedly reduce accessibility of the basin in comparison to the proposed project.

- A Parks Highway access connection would increase accessibility even more than proposed.

- An access route to Watana south of the river could reduce the suitability of Prairie Creek as a fishery for brown bear.

- Adoption of the natural-gas generation configuration would reduce loss of wildlife habitat about sixfold in comparison with the proposed project.

- Adoption of the combined hydro-thermal generation configuration would result in double the habitat loss of the proposed project, as well as loss of the Prairie Creek fishery.

- Adoption of the coal generation configuration would reduce loss of wildlife habitat about fourfold in comparison to the proposed project.

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