KNIK ARM CROSSING

TECHNICAL MEMORANDUM No. 20

Biological Secondary Impact Analysis

March 1, 1985

U.S. Department of Transportation
Federal Highway Administration

Alaska Department of Transportation
and Public Facilities

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BIOLOGICAL SECONDARY IMPACT ANALYSIS

INTRODUCTION

During the process of assessing impacts to the natural environment from the proposed Knik Arm Crossing Project, it was determined that secondary impacts to biological resources could be greater than those caused directly by the crossing and its approach roads. For purposes of this study, secondary impacts are defined as impacts that would be induced by the crossing through increased or shifted residential, commercial and industrial development, increased or shifted recreational use and other changing human patterns. The area of primary concern is located within the Willow Subbasin areas of the Matanuska-Susitna Borough. This study attempts to predict and quantify secondary impacts that might occur to habitats used by key animal species. Because of budget and time limitations, existing information was utilized to the greatest degree possible.

METHODS

Induced Development Scenario

A map (1 inch to the mile) delineating probable locations of induced and shifted development was prepared by the Knik Arm Crossing Project consultant team. This map plots on minimum 10 acre grid cells the location of projected development in the year 2010 for possible growth scenarios associated with the Downtown and Elmendorf crossing alternatives. The procedures and assumptions used to develop the above growth scenario are described in Appendix A.

Selection of Evaluation Species

Fifteen species (Table 1) were selected by the U.S. Fish and Wildlife Services (USFWS) in cooperation with the Alaska Department of Fish and Game as the basis for evaluating impacts for the Knik Arm Crossing Project. The rationale for species selection is explained in a Mitigation Statement prepared by USFWS (1984). Generally, species were selected because of high public interest or economic value, or because they utilize habitats having significant ecological values.

Evaluation of Impact to Big Game and Upland Birds

Impacts to habitats used by the upland evaluation species (moose, black bear and spruce grouse) were evaluated using two specialized maps produced by the Willow Subbasin study program (U.S. Department of Agriculture 1981): HEP Habitat Model for moose and snowshoe hare; and HEP Habitat Model for red squirrel and spruce grouse. These computer generated maps (1 inch to the mile) are based on groupings of vegetation types and model the habitat suitability for the above species on minimum 10 acre grid cells based on the ability of the habitats to satisfy life requisites. The rationale for the models is described by USFWS (1981).

A workshop attended by agency resource specialists was held on September 12, 1984 to assign values to the habitat groupings used in the above models (Tables 2 and 3) and to establish assumptions to be used to quantify impacts from induced development and increased recreational use. Although there is no HEP habitat map for black bear, the moose model was adapted for the black bear by assigning habitat values relative to bear suitability to the same habitat groupings used in the moose model.

The basic procedure involved overlaying the development scenario map over the habitat model maps and observing the habitats that would be affected by the proposed development. Assumptions used in quantifying habitat withdrawal were as follows:

TABLE 1

Evaluation species for the Knik Arm Crossing Project

Common Name	Scientific Name
Moose	Alces alces
Black bear	Ursus americanus
Beaver	Castor canadensis
Common loon	Gavia immer
Trumpeter swan	Cygnus buccinator
Lesser Canada goose	Branta canadensis parvipes
Mallard/Pintail	Anas platyrhynchos /A acuta
Spruce grouse	Dendragapus canadensis
Lesser sandhill crane	Grus canadensis canadensis
Yellowlegs	Tringa sp.
Chinook Salmon	Oncorhychus tshawytscha
Coho salmon	Oncorhynchus kisutch
Sockeye salmon	Oncorhynchus nerka
Rainbow trout	Salmo gairdneri
Dolly varden	Salvelinus malma

TABLE 2

Habitat evaluation[3] matrix for moose and black bear-
Knik Arm Crossing Project secondary impact analysis

	SCS Vegetation Types [1]	Percent Cover In Willow Subbasin [2]	Moose Habitat Value	Black Bear Habitat Value
Tundra	65 66, 67	15.09	M	L
Grasslands	63, 64	14.38	M	M
Low shrub	51, 62, 69	6.86	H	H
Tall alder	60	2.67	M	M
Tall alder-willow	61	2.45	H	H
Closed cottonwood	28	0.35	M	M
Closed mixed & spruce forests	26, 42	1.97	M	M
Other forests	21, 25, 31, 33, 41, 43, 22, 24, 27, 29, 32, 34, 35, 36	44.21	M	M
Water, disturbed, non-vegetated	70-97	12.03	L	L

1 See Appendix B
2. From U.S. Dept. of Agriculture, 1981.
3. Value Ratings: H = High M = Medium L = Low N=Not utilized

TABLE 3

Habitat evaluation[3] matrix for spruce grouse-
Knik Arm Crossing Project secondary impact analysis

Habitat Type	SCS Vegetation Types[1]	Percent Cover In Willow Subbasin[2]	Spruce Grouse Suitability	Spruce Grouse Habitat Value
Shrub tundra	66	0.13	not utilized	N
Other Tundra and grasslands	63, 64, 65 66, 67	29.34	not utilized	N
Willow/alder and Willow/birch shrublands	61, 62	6.03	not utilized	N
Other shrublands	60, 69	5.95	not utilized	N
Mixed and black spruce forests	24, 26, 29 41, 43, 32 34, 35, 36	38.86	year-round food & cover; reproduction	H
Deciduous forests	22, 27, 28 32, 34	3.68	not utilized	N
Other coniferous forests	21, 25, 31 33, 42	3.98	winter food & cover; marginal spring/summer/fall food; reproduction	M
Water, disturbed, non-vegetated	70-97	12.03		L

[1]See Appendix B
[2]From U.S.Dept. of Agriculture, 1981
[3]Value Ratings: H=High M=Medium L=Low N=Not utilized

1. In the situation were a development grid cell overlayed a habitat cell, the habitat beneath the cell was considered 100 percent withdrawn from productivity.

2. In the situation where an undeveloped cell(s) was completely surrounded by developed cells, the undeveloped cell(s) was considered 100 percent withdrawn for black bear and 50 percent withdrawn for moose and spruce grouse.

3. To account for impacts to undeveloped areas adjoining development areas, an additional area factor - equal to 25 percent of developed surface area for moose and 50 percent of developed surface area for black bear and spruce grouse - was added to the above.

Evaluation of Impacts to Waterbirds

The impact analysis for water - and wetland-oriented evaluation species (common loon, trumpeter swan, lesser Canada goose, mallard/pintail, lesser sandhill crane and yellowlegs) was based on the development scenario map in combination with a computer-generated wetland map from the Willow Subbasin study program (U.S. Soil Conservation Service 1981). A workshop attended by resource specialists was again conducted to assign habitat values (Table 4) to each wetland type for each evaluation species and to establish assumptions to be used in quantifying impact.

The map overlay procedure was again used and surface areas of impacted wetland habitats were estimated according to the following assumptions:

1. In the situation where residential or industrial development is projected to occur within wetland habitats, then the impacted area was considered as 100 percent of the developed area.

TABLE 4

Habitat evaluation matrix[1] for waterbird evaluation species - Knik Arm Crossing Project secondary impact analysis

	Evaluation Species					
Wetland Type[2]	Common Loon	Trumpeter Swan	Lesser Canada Goose	Mallard Pintail	Lesser Sandhill Crane	Yellowlegs
Forested needle leaved evergreen	N	N	N	N	N	M
Forested broad - leaved deciduous	N	N	N	N	N	L
Forested mixed	N	N	N	N	N	M
Scrub/shrub broad - leaved deciduous	N	L	L	M	M	M
Emergent persistent	N	L	L	L	M	M
Intertidal scrub	N	N	L	M	M	M
Intertidal emergent - Grassland	N	N	M	L	M	M
Intertidal emergent - Marsh	L	M	M	L	L	M
Intertidal mud flat	L	L	M	M	L	M
Lower perennial streambed	N	L	L	M	N	N
Landlock Lakes Larger than 10 acres	M	H	L	M	N	M
Non - Landlocked Lakes Larger Than 10 Acres	H	H	L	M	N	N
Lakes Less Than 10 Acres	L	L	L	M	N	M

[1]Value Ratings:
H = High
M = Medium
L = Low
N = Not utilized

[2]From U.S.Department of Agriculture, 1981.

2. In the situation where development is projected to occur immediately adjacent to a wetland habitat, then 25 percent of the wetland block (10-acre cell) was considered withdrawn from productivity for each adjoining development block. In other words, if a wetland block was surrounded on three sides by non-wetland development blocks, then 75 percent of the wetland was considered withdrawn from productivity.

Open water (lake) habitats were analyzed separately by overlaying the development scenario map on USGS topographic maps and noting the approximate proportion of the lake shore that would be developed. Lake surface area was estimated by superimposing a grid of 10 acre cells over the lake and counting the cells inside the lake boundary. All lakes less than 10 acres in size were considered to be 8 acres. Surface area of open water areas impacted was obtained by multiplying the total lake area by the percentage of developed shoreline.

To provide a more realistic evaluation of impact to lake nesting habitat used by common loons and trumpeter swans, a supplemental analysis was performed that considered open water habitats only. Trumpeter swans are highly territorial and nearly always nest with one pair of adults to a lake, except on very large lakes with complex shorelines (Hanson et al. 1971). Swans are also very sensitive to human disturbance; periodic human activity such as canoeing or more than a few cabins on a lake greater than 10 acres will discourage the birds from nesting or interfere with reproductive success (Timm 1981; Bailey, personal communication). Therefore, any lake greater than 10 acres with more than 10 percent shoreline development and probable road access was considered lost to swan productivity. Each lake was assumed to provide habitat for only one pair of swans regardless of size; therefore, one open water "habitat unit" is equivalent to one lake.

Common loons are also territorial, requiring about 100 acres of open water per reproducing pair in large lakes while smaller lakes from 15 to 100 acres are generally only occupied by one pair (Titus and Van Druff 1981).

For purposes of this analysis, lakes less than 150 acres were considered as one loon "habitat unit" while lakes greater than 150 acres were considered to contain one "habitat unit" for each 100 acres of open water. Common loons will tolerate and/or adapt to substantial human disturbance but extensive shoreline development is detrimental (Titus and Van Druff 1981, Heimberger et al. 1983, and Sutcliffe 1978). Lakes smaller than 150 acres (but greater than 10 acres) with less than 30 percent shoreline development were considered to be adequate loon nesting habitat, while small lakes with greater than 30 percent shoreline development were considered to be 100 percent lost to loon productivity. Lakes of 150 acres or larger would incur no loss of productivity with up to 30 percent shoreline development; 30 to 60 percent shoreline development would result in a 50 percent reduction in productivity, and greater than 60 percent shoreline development would cause the lake to be entirely lost to loon production. For example, a 200 acre lake with 90 percent shoreline development would result in the loss of 2 open water loon nesting units.

Evaluation of Impacts to Aquatic Species

A third workshop was held on August 25 to categorize and assign values to the various aquatic habitats within the potential impact area (Table 5) and to establish approaches to quantifying secondary impacts. Three situations were identified that appeared to be quantifiable.

1. In the case of residential development of lakeshore property, it was concluded that an amount of littoral habitat would be lost to productivity (especially in regard to rearing fish). For any specific lake the surface area of habitat lost was assumed to be equal to 10 percent of the length of developed shoreline multiplied by a band of littoral area 30 feet wide. Developed shoreline length was estimated by first estimating total shoreline length then multiplying by the percentage of the lake shore that would be developed as determined from the development scenario map. Total shoreline length of larger lakes was estimated from topographic maps using a map wheel measuring device. Total shoreline length of

TABLE 5

Habitat evaluation[1] matrix for aquatic evaluation Species-
Knik Arm Crossing Project secondary impact analysis

	Evaluation Species										
	Chinook Salmon		Coho Salmon		Sockeye Salmon		Rainbow Trout		Dolly Varden		Beaver
	Spawning	Rearing	Swawning	Rearing	Spawning	Rearing	Spawning	Rearing	Spawning	Rearing	
Streams											
Little Susitna River N. of Parks Hwy.	M	M	H	H	L	L	M	M	M	M	M
3 mi. below Mackenzie Rd. to Parks Hwy.	M	M	L	H	L	L	L	M	L	L	H
Inlet To Mackenzie Rd. (3 mi. below)	N	L	N	L	N	L	N	L	N	L	M
Little Susitna Tributaries											
My Creek	N	L	N	H	N	N	?	M	?	L	H
Hourglass Lake Outlet	N	L	N	H	N	N	N	M	N	L	M
Lake Creek	N	L	N	H	L	L	M	M	L	L	H
Other unnamed	N	L	L	H	L	L	M	M	M	M	M
Goose Creek	N	N	L	M	N	N	M	M	L	L	L
Mule Creek	N	N	M	M	N	N	N	N	L	L	L
Fish Creek	L	L	M	H	L	L	M	M	L	L	M
Meadow Creek	N	N	M	H	L	L	M	M	L	L	L
Lucille Creek	N	N	L	H	N	N	L	L	L	L	M
Fish Creek (Susitna drainage)	M	M	L	H	L	L	M	M	L	L	H
Red Shirt Lake tributaries	N	N	L	H	L	L	M	M	L	L	H
Lakes											
Big Lake Complex	N	N	L	H	H	H	N	H	H	H	L
Red Shirt Lake Complex	N	N	N	H	M	M	N	M	L	L	L
Landlocked lakes[2]	N	N	N	N	N	N	N	N	N	N	L
Connected lakes	N	N	L	H	L	M	N	M	L	L	L

[1]Value ratings:
H = high
M = medium
L = low
N = not utilized

[2]Some specific lakes are stocked on a maintenance basis usually with rainbow trout.

smaller lakes was estimated from surface area (as measured for the waterbird analysis) by assuming that shoreline length was equal to the circumference of a circle with the appropriate area plus 20 percent.

The above habitat loss was intended to include impacts from shoreline disturbance (boating, swimming, docks, etc.,), as well as impacts from dredge and fill of wetlands contiguous to lake shores.

2. In the case where stream bank and bed degradation are caused by heavy fishing pressure (Little Susitna River only), it was concluded that within an impact zone of 2 miles upstream and downstream from probable access points, 20 percent of the rearing productivity could be lost on the side of the river used by fishermen. The impact zone was assumed to be 10 feet wide. Possible future access points were identified by reviewing land use and transportation plans and by selecting potential corridors to the Little Susitna River from new roadways.

3. An additional impact factor relating to loss of wetland rearing habitat was considered as a result of activities that are not specifically shoreline related, such as road development and other land uses. Such impacts were quantified by first identifying the drainages in the study area where anadromous fish rearing was likely to occur (any waterbody connected to saltwater), and, second by identifying wetlands within these drainages from the Willow Subbasin wetland map. Surface area loss of rearing wetlands was assumed to be equal to 25 percent of the wetland cell for each contacting development cell (same procedure as used for waterbird Habitats).

4. Regarding beaver habitat, it was assumed that where streams potentially supporting beaver are included within a grid cell projected for development then beaver habitat would be 100 percent lost within the development cell. If beaver habitat is present in an undeveloped cell adjacent to a developed cell then a

25 percent loss of habitat would occur for each side of the undeveloped cell that contacts a developed cell. The amount of habitat lost would be quantified according to the surface area of the affected cell (in the same way that the other species are considered) even though the surface area concept is not as applicable to beaver as to other species that distribute themselves more uniformly. Loss of lake habitat to beaver use was computed using the same method described for quantifying impact to littoral fish habitat from shoreline development except that 100 percent of developed shoreline was used in the calculations rather than 10 percent and a 100-foot band of affected shoreline was assumed rather than a 30-foot band.

RESULTS AND DISCUSSION

Big Game and Upland Birds

Tables 6, 7 and 8 provide estimates of the surface area of various habitats (per the HEP habitat maps) that could be withdrawn from productivity as a result of development in the year 2010 for moose, black bear and spruce grouse respectively. Acreage is provided for each of the four development scenarios considered in this study. Table 9 provides surface area of habitats according to value to each of the evaluation species.

The mixed spruce/birch forest is by far the most common upland habitat type in the study area (and in areas suitable for development). Tables 6-9 strongly reflect the dominance of this type. The mixed forests were considered to have medium value to moose and black bear. Relatively little of the shrub habitat types, important to both moose and black bear, would be impacted. Spruce grouse favor the mixed forest types and, consequently, nearly all the lost habitat would be considered high value for this species.

Table 6

Surface area (acres) of terrestrial habitats potentially lost to moose productivity as a result of shifted or induced development from the Knik Arm Crossing Project

Habitat Type	Development Scenario			
	Elmendorf Low	Elmendorf Mid-range	Downtown Mid-range	Downtown High
Tundra	0	0	0	0
Grasslands	13	13	63	88
Low shrub	13	13	113	113
Tall alder	0	0	0	0
Tall alder-willow	20	20	20	20
Closed cottonwood	0	0	0	0
Closed mixed & Spruce forests	743	843	888	1055
Other forests	6848	8110	10962	14982
Disturbed, non vegetated	105	235	272	542

TABLE 7

Surface area (acres) of terrestrial habitats potentially lost to black bear as a result of shifted or induced development from the Knik Arm Crossing Project

Habitat Type	Development Scenario			
	Elmendorf Low	Elmendorf Mid-range	Downtown Mid-range	Downtown High
Tundra	0	0	0	0
Grasslands	15	15	115	165
Low shrub	15	15	195	195
Tall alder	0	0	0	0
Tall alder-willow	40	40	40	40
Closed cottonwood	0	0	0	0
Closed mixed & Spruce forests	895	1015	1075	1280
Other forests	8705	10240	13815	18815
Disturbed, non vegetated	130	290	345	745

TABLE 8

Surface area (acres) of terrestrial habitats potentially lost to spruce grouse productivity as a result of shifted or induced development from the Knik Arm Crossing Project

Habitat Type	Development Scenario: Elmendorf Low	Elmendorf Mid-range	Downtown Mid-range	Downtown High
Shrub tundra				
Other Tundra and grasslands	15	15	55	75
Willow/alder and Willow/birch shrublands				
Other shrublands	75	90	205	335
Mixed and black spruce forests	9405	11395	15375	21020
Deciduous Forests	+495*	+290 *	+245*	190
Other coniferous forests	0	0	0	180
Water, disturbed, non-vegetated	0*	205	235	625

* Represents a gain in habitat area as a result of development shifting from one area to another.

TABLE 9

Surface area (acres) of various value habitats that could be lost to productivity for terrestrial evaluation species as a result of shifted or induced development from the Knik Arm Crossing Project

Habitat Value	Development Scenario	Evaluation Species		
		Moose	Black Bear	Spruce Grouse
High	Elmendorf Low	33	55	9405
	Elmendorf Mid-range	33	55	11395
	Downtown Mid-range	133	235	15375
	Downtown High	133	235	21020
Medium	Elmendorf Low	7604	9615	0
	Elmendorf Mid-range	8966	11270	0
	Downtown Mid-range	11913	15005	0
	Downtown High	16125	20260	180
Low	Elmendorf Low	105	130	0
	Elmendorf Mid-range	235	290	205
	Downtown Mid-range	272	345	235
	Downtown High	542	745	625
Not Utilized	Elmendorf Low	0	0	+405*
	Elmendorf Mid-range	0	0	+185*
	Downtown Mid-range	0	0	15
	Downtown High	0	0	600

* Represents a gain in habitat area as a result of development shifting from one area to another.

Waterbirds

Surface area of the various wetland types that could be lost to productivity for each of the development scenarios is presented in Table 10. Table 11 translates the acreage into quantities of habitat lost to each waterbird evaluation species according to habitat value. It can be seen from the tables that, except for lake habitats, no high quality wetlands would be impacted. The low and medium quality wetland habitats that would be affected would consist primarily of freshwater shrub and emergency types. High quality intertidal wetlands are primarily located within the state game refuge system and would be avoided by development.

High and medium quality lake habitats used for nesting and rearing by common loons and trumpeter swans are analyzed in more meaningful form in Table 12. Substantial numbers of lakes potentially used by these birds for nesting would probably be made unavailable because of development.

Aquatic Species

The surface area of littoral habitat that would be lost to productivity from shoreline development is presented in Table 13. Table 14 presents the area of additional wetland habitats (potentially used by rearing fish) that could be lost to productivity as a result of other development activities such as construction activities that require wetland fill.

In addition to habitat withdrawals itemized in Tables 13 and 14, 2.9 acres of stream habitat on the Little Susitna River was considered lost under all scenarios because of habitat destruction from fishing pressure adjacent to probable access points. This habitat loss was based on the assumption that three access points would be heavily utilized in the year 2010 south of the Parks Highway in addition to the one existing access point near the west end of Mackenzie Road. The estimate of access points is based on a consideration of existing and probable future roadways, the presence of existing trails and seismic lines, and judgement regarding the behavior of fishermen. The access scenario upon which this analysis is based

TABLE 10

Surface area (acres) of wetland and open water habitats potentially lost to productivity as a result of shifted or induced development from the Knik Arm Crossing Project

	Development Scenario			
Wetland Type	Elmendorf Low	Elmendorf Mid-range	Downtown Mid-range	Downtown High
Forested needle-leaved evergreen	70	75	100	150
Forested broad - leaved deciduous	0	0	0	0
Forested mixed	98	120	158	207
Scrub/shrub broad - leaved deciduous	100	127	227	349
Emergent persistent	88	105	170	274
Intertidal scrub	0	0	0	0
Intertidal emergent - Grassland	0	0	0	0
Intertidal emergent - Marsh	0	0	0	0
Intertidal mud flat	7.5	15	27	27
Lower perennial streambed	0	0	0	0
Landlock Lakes Larger than 10 acres	490	579	821	1001
Non-Landlocked Lakes Larger Than 10 Acres	323	343	347	497
Lakes Less Than 10 Acres	57	60	100	145

TABLE 11

Surface area (acres) of various value waterbird habitats that would be lost to productivity as a result of shifted or induced development from the Knik Arm Crossing Project

Habitat Value	Development Scenario	Waterbird Evaluation Species					
		Common Loon	Trumpeter Swan	Lesser Canada Goose	Mallard/ Pintail	Lesser Sandhill Crane	Yellowlegs
High	Elmendorf Low	323*	813*	0	0	0	0
	Elmendorf Mid-range	343*	922*	0	0	0	0
	Downtown Mid-range	347*	1168*	0	0	0	0
	Downtown High	497*	1498*	0	0	0	0
Medium	Elmendorf Low	490*	0	8	978	188	1234
	Elmendorf Mid-range	579*	0	15	1124	232	1424
	Downtown Mid-range	821*	0	27	1522	397	1950
	Downtown High	1001*	0	27	2019	623	2650
Low	Elmendorf Low	65	253	1058	88	8	0
	Elmendorf Mid-range	75	307	1214	105	15	0
	Downtown Mid-range	127	524	1665	170	27	0
	Downtown High	172	795	2266	274	27	0
Not Utilized	Elmendorf Low	356	168	168	168	1038	0
	Elmendorf Mid-range	427	195	195	195	1177	0
	Downtown Mid-range	655	258	258	258	1526	0
	Downtown High	980	357	357	357	2027	0

*Open water nesting and rearing habitat - see also Table 11

TABLE 12

Open water habitat units* lost to productivity for territorial lake-oriented waterbirds as a result of shifted or induced development from the Knik Arm Crossing Project

Habitat Value	Development Scenario	Evaluation Species	
		Common Loon	Trumpeter Swan
High	Elmendorf Low	9	20
	Elmendorf Mid-range	9	26
	Downtown Mid-range	10	32
	Downtown High	13	37
Medium	Elmendorf Low	11	0
	Elmendorf Mid-range	14	0
	Downtown Mid-range	21	0
	Downtown High	24	0

* A Habitat unit represents the area of open water required by a pair of nesting loons or swans to achieve successful reproduction. In most cases 1 habitat unit is equivalent to 1 lake.

TABLE 13

Littoral habitat (acres) potentially lost to productivity to aquatic organisms as a result of shoreline development on lakes and streams induced by the Knik Arm Crossing Project

	Development Scenario			
	Elmendorf Low	Elmendorf Mid-range	Downtown Mid-range	Downtown High
Little Susitna River (below Parks Highway)	0	0	0	0
Little Susitna Tributaries	0.1	0.1	0.1	0.3
Goose Creek	0	0	0	0
Mule Creek	0.05	0.05	0.1	0.15
Fish Creek	0.1	0.1	0.1	0.2
Meadow Creek	0	0	0	0
Lucille Creek	0	0	0	0
Fish Creek (from Red Shirt Lake)	0.23	0.23	0.23	0.23
Red Shirt Lake Tributaries	0	0	0.1	0.1
Big Lake Complex	0.3	0.3	0.3	0.3
Red Shirt Lake	0.4	0.4	0.4	0.4
Connected Lakes	0.8	0.9	0.9	1.7
Landlocked Lakes	6.1	7.0	10.2	12.8

TABLE 14

Wetland fish rearing habitat (acres) potentially lost to productivity as a result of shifted or induced development from the Knik Arm Crossing Project.

	Development Scenario			
	Elmendorf Low	Elmendorf Mid-range	Downtown Mid-range	Downtown High
Little Susitna River (below Parks Highway	7.5	7.5	12.5	15.0
Little Susitna Tributaries	5.0	5.0	10.0	20.0
Goose Creek	2.5	2.5	5.0	7.5
Mule Creek	5.0	05.	10.0	10.0
Fish Creek	5.0	5.0	5.0	22.5
Meadow Creek	0	0	0	0
Lucille Creek	0	0	0	0
Fish Creek (from Red Shirt Lake)	27.5	27.5	27.5	27.5
Red Shirt Lake Tributaries	0	0	5.0	10.0
Big Lake Complex	2.5	7.5	17.5	25.0
Red Shirt Lake	7.5	7.5	7.5	15.0
Connected Lakes	0.	0.	2.5	20.0
Landlocked Lakes	0	0	0.	0

includes access to the Little Susitna River at the following points:

- Bridge crossing from the proposed east-west corridor connecting the Knik Arm Crossing Houston Connector with the Fish Creek agricultural area near the west end of the existing Mackenzie Road.

- A trail access heading east to the river from the proposed Willow-Point Mackenzie Road (north-south corridor through the Fish Creek Management Unit) - access might logically occur several miles north of the Iditarod Trail crossing.

- Access via a seismic trail from the northern portion of the Houston Connector west to the river near the Horseshoe Lake complex.

Habitat withdrawals from the above sources are combined in Table 15 and presented according to value to the key species. A separate analysis was performed for beaver and this species is also included in Table 15. To simplify the analysis, the habitat values assigned to waterbodies for specific species were those for the life stage which has the highest value, rather than separating spawning and rearing habitat as in Table 5. With the exception of coho salmon, high quality fish habitats would not be greatly affected by the projected development activities relative to the other value categories. High value coho salmon rearing habitat is associated with nearly all the connected lakes and streams in the study area and, thus, appears to be the dominant fisheries value that will be affected.

Impact from shoreline development alone would affect primarily the small, landlocked lakes near the road corridors. These lakes generally have low value to fish; however, they may have a high future recreation potential if development pressure justifies "put and take" fisheries supported by stocked fish. Therefore, habitat impacts to landlocked lakes might represent a loss to the enhancement potential to managed fisheries that are frequently developed in suburban areas.

TABLE 15

Surface area (acres) of aquatic habitat that would be lost to productivity as a result of shifted or induced development from the Knik Arm Crossing Project according to evaluation species and habitat value

Habitat Value	Development Scenario	Evaluation Species: Chinook Salmon	Coho Salmon	Sockeye Salmon	Rainbow Trout	Dolly Varden	Beaver
High	Elmendorf Low	0	59.8	2.8	2.8	2.8	55
	Elmendorf Mid-range	0	64.9	7.8	7.8	7.8	55
	Downtown Mid-range	0	92.5	17.8	17.8	17.8	70
	Downtown High	0	161.1	25.3	25.3	25.3	70
Medium	Elmendorf Low	38.1	7.6	8.7	59.5	5.1	32.5
	Elmendorf Mid-range	38.1	7.6	8.8	59.6	5.1	32.5
	Downtown Mid-range	43.1	15.1	11.3	84.7	10.1	35.0
	Downtown High	45.6	17.7	37.1	130.8	20.3	115.0
Low	Elmendorf Low	10.2	0	47.3	0	59.5	255.8
	Elmendorf Mid-range	10.2	0	47.3	0	59.6	289.1
	Downtown Mid-range	15.2	0	63.4	0	79.7	433.3
	Downtown High	43.0	0	98.7	0	133.2	549.2
Not Utilized	Elmendorf Low	25.2	6.1	13.7	11.2	6.1	0
	Elmendorf Mid-range	31.2	7.0	14.6	12.1	7.0	0
	Downtown Mid-range	59.5	10.2	25.3	15.3	10.2	0
	Downtown High	103.0	12.8	30.5	35.5	12.8	0

CAUTIONS

It should be strongly emphasized that the figures presented in this report are only intended to provide a suggestion of the kinds of habitat impacts that might result from future development stimulated by the Knik Arm Crossing. The results are only as accurate as the assumptions that went into developing them. While the development scenario map that served as the basis for this analysis was constructed on the basis of informed professional judgement, the actual placement of individual "development cells" was to some extent arbitrary.

The workshop approach that was used to help develop value ratings and impact assumptions provides some confidence in their reasonableness. Nevertheless, the decisions reached in the workshops were often based on scanty background information and assumptions tended to emphasize resource values. Therefore, it is likely that the impacts described in this report represent a worst case situation. Additionally, existing laws and regulations will provide some degree of protection for habitats and associated species especially when high values are involved.

REFERENCES

Hanson, H.A., P.E. Shepherd J.G. King and W.A. Troyer. 1971. The trumpeter swan in Alaska. Wildl. Monogr. No. 26.

Heimberger, M., D. Euler, and J. Barr. 1983. The impact of cottage development on common loon reproductive success in central Ontario. Wilson bull. 95 (3): pp.431-439.

Sutcliffe, S.A .1978. Changes in status and factors affecting common loon populations in New Hampshire. Trans. 35th N.E. Fish and Wildl. Conf., N.E. Sect. Wildl. Soc. pp. 319-224.

Timm, D.E. 1981. Relationship between trumpeter swan distribution and cabins in the Susitna basin. Proc. Sixth Trumpeter Swan Society Conference: pp. 46-48.

Titus, J.R. and L.W. Van Druff. 1981. Response of the common loon to recreational pressure in the the Boundary Waters Canoe Area, northeastern Minnesota. Wildl. Monogr. No. 79.

U.S. Department of Agriculture. 1981. Susitna River Basin Study Alaska, Willow Subbasin Final Report. Anchorage.

U.S. Fish and Wildlife Service. 1981. Technical Appendix - Fish and Wildlife Resources. Susitna River Basin Cooperative Study, Willow Subbasin Portion.

Appendix A

KNIK ARM CROSSING **INTEROFFICE CORRESPONDENCE**

TO: FILE **FROM:** John Page
LOCATION: **LOCATION:**

SUBJECT: Approach to Determining Likely Location for Mat-Su Borough Growth

DATE: **FILE:** 10/17/84

This memo describes the approach and assumptions used in identifying the likely location of residential growth increases between 1983 and 2010 in the Mat-Su Borough and the change that would result from a crossing.

Seven areas of the Borough were considered:

- Point MacKenzie
- Knik/Goose Bay
- Fish Creek
- Willow/Nancy Lake
- Big Lake/Houston
- Wasilla/Fishhook
- Palmer/Sutton

These areas are illustrated on the attached map and are termed in the analysis "Sub-Regional Areas" (SRA's).

The approach to growth mapping was as follows:

1. Dwelling Unit Growth

   a. No-Crossing. Total growth is similar to that forecast in the Matanuska-Susitna Borough Comprehensive Plan (draft) (DOWL Engineers, February 1983) for 2001. To this was added growth to 2010 assuming a growth rate slightly less than that before 2001.

   b. Elmendorf Crossing--Low. This low estimate of growth that includes crossing related growth shifts from Anchorage to the Mat-Su Borough was developed by the Institute of Social and Economic Research (ISER) for the Municipality of Anchorage (MOA). Holding capacity for development in the Mat-Su Borough in relation to regional holding capacity was the primary factor in determining the growth shift. This scenario assumed that only private and native lands would be available for development and densities would be 1 to 0.2 dwelling units per acre, a low holding capacity for development.

   c. Elmendorf Crossing--Medium. This estimate of shifted growth was developed by the Knik Arm crossing team. Holding capacity in the Mat-Su Borough in relation to that in the region was again a prime factor in the amount of growth shifted. Accessibility was another factor. Longer distances to central Anchorage tend to suppress development outside the bowl. All lands with a medium

to high capability for residential development (based on Willow Sub-basin grid-cell mapping) minus those set aside or to be set aside for agriculture or recreation were assumed to be available for development. Densities of one to two dwelling units per acre were assigned. The change in the definition of available lands and the greater densities increased the holding capacity in the Mat-Su Borough above that used in the low estimate.

d. Downtown Crossing--Medium. This estimate was also made by the Knik Arm crossing team. The same assumptions as the Elmendorf--Medium were used except the distance to central Anchorage was shorter due to crossing location, increasing accessibility and the amount of growth shifted to the Mat-Su Borough.

e. Downtown Crossing--High. This estimate was prepared by ISER/MOA. It assumes that one-half of the Borough owned lands are available for development, as well as all private and native owned. A density of two dwelling units per acre with a small amount of land for multi-family housing at 15 dwelling units per acre was used. This scenario assumes the greatest holding capacity.

The two estimates completed by the Knik Arm crossing team are believed by the team to properly reflect the differences between Elmendorf and Downtown crossing accessibility. The ISER estimates were developed for the Municipality of Anchorage and not for the the crossing team. They are being included at the request of the Municipality as the most likely growth shift extremes. The decision to use these four sets of crossing forecasts was made jointly by the Municipality of Anchorage, Anchorage Metropolitan Area Transportation Study, Mat-Su Borough, ISER, and the Knik Arm crossing team.

The crossing team model breaks down the growth shift estimates into the SRA's. See the attached map. The ISER forecasts were broken into these same areas by using the Elmendorf--Medium percentage distribution for Elmendorf--Low and the Downtown--Medium percentage distribution for Downtown--High.

2. Development Density. Two sets of densities were used for mapping the forecasts. For residential growth that would occur with No-Crossing, densities identified in the Borough Comprehensive Plan were used:

Sub-Regional Area	Dwelling Units Per Acre
Point MacKenzie	0.28
Knik/Goose Bay	0.44
Fish Creek	0.28
Willow/Nancy Lake	0.28
Big Lake/Houston	0.37
Wasilla/Fishhook	1.00
Palmer/Sutton	1.00

A rural employment density of 0.087 acres per employee was also assumed for No-Crossing non-residential growth. Higher densities agreed to by the Mat-Su Borough and the Knik Arm crossing team were used for crossing generated growth. The higher densities reflect the higher demand for land resulting from improved access to Anchorage. They are:

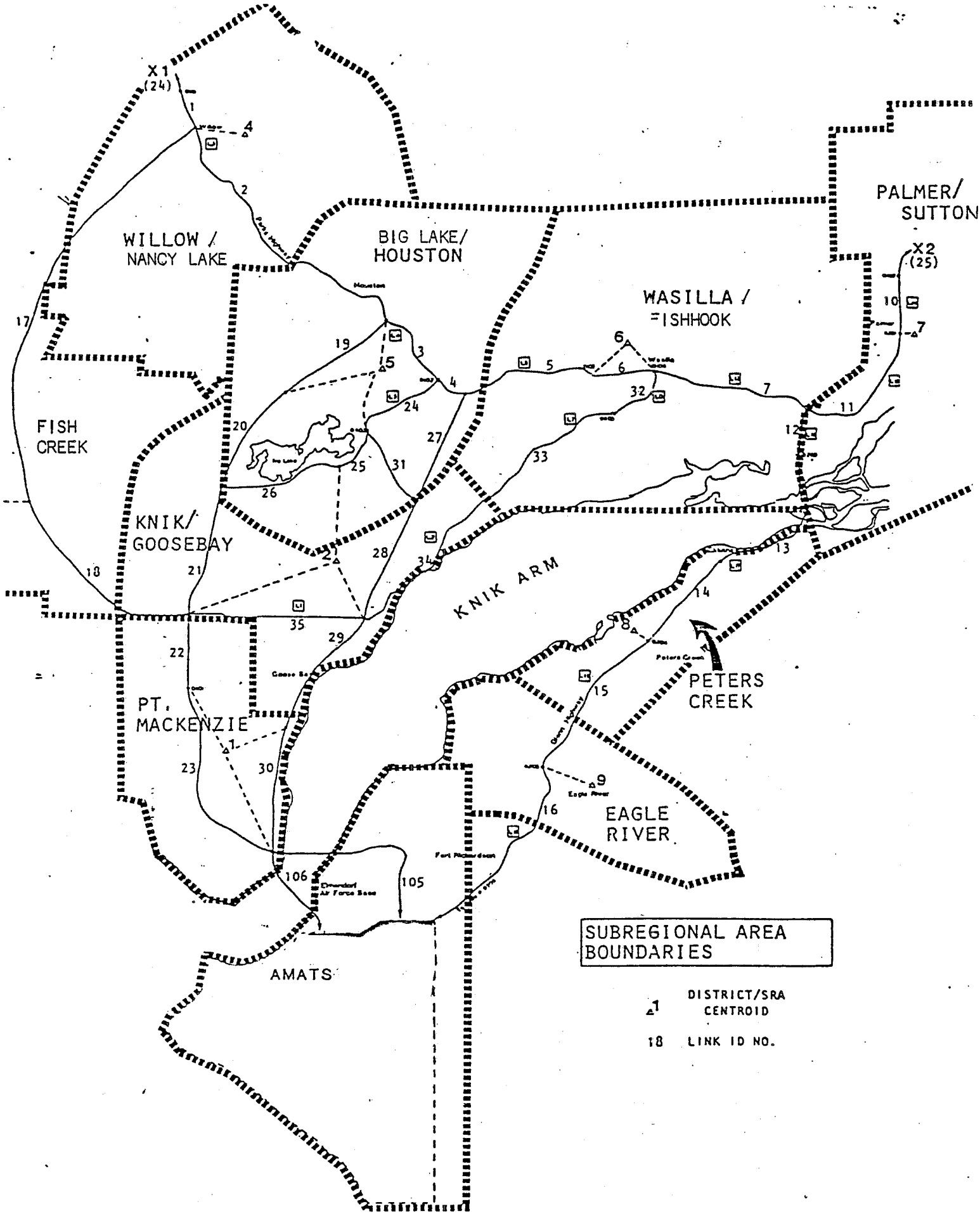
Sub-Regional Area	Dwelling Units Per Acre
Point MacKenzie	2
Knik/Goose Bay	1.5
Fish Creek	1
Willow/Nancy Lake	1
Big Lake/Houston	2
Wasilla/Fishhook	2
Palmer/Sutton	1.5

For Crossing-related employment growth a rural density of 0.087 employees per acre was assumed except in Point MacKenzie, Wasilla/Fishhook, and Palmer/Sutton where a suburban density similar to Eagle River of 0.048 employees per acre was assumed.

3. Number of Grid Cells. This was determined by dividing the SRA forecasts (dwelling units) by anticipated average densities (dwelling units per acre). This result (acres) was divided by 10 acres per grid.

4. Grid Cell Assignment. The no-crossing growth was first assigned to grid cells on a "1 inch equals one mile" Willow Sub-basin grid-cell map. The purpose of the no-crossing grid assignment was to assure crossing-related development was not assigned to land likely to develop without a crossing. The additional growth with the Elmendorf--Low forecast was then marked using a different color. The Elmendorf--Medium, Downtown-- Medium, and Downtown--High were then each in turn marked. The criterion used for assigning development to grid cells were:

- Highway access would be controlled. Growth was clustered around probable intersection locations.
- Grids were assigned only if they had a medium to high capability for residential development based on Willow Sub-basin grid-cell mapping.
- Development would occur in the Point MacKenzie area in areas designated in the Point MacKenzie Area Meriting Special Attention (AMSA) Phase II Report.
- Development would occur only in areas designated for residential development by the Mat-Su Borough Comprehensive Plan and in Fish Creek by the Fish Creek Management Plan.
- Only grids in road-served areas or areas planned for road service in the above plans were assigned.
- Lake-front property meeting all of the other criteria was generally assumed to develop.


X1
(24)
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WILLOW /
NANCY LAKE
BIG LAKE/
HOUSTON
PALMER/
SUTTON
WASILLA /
FISHHOOK
FISH
CREEK
KNIK/
GOOSEBAY
KNIK ARM
PT.
MACKENZIE
PETERS
CREEK
EAGLE
RIVER
AMATS
SUBREGIONAL AREA
BOUNDARIES
DISTRICT/SRA
CENTROID
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Appendix B

VEGETATION TYPES USED BY U.S. SOIL CONSERVATION SERVICE IN WILLOW SUBBASIN STUDY PROGRAM

FOREST & WOODLAND (> 10% Crown Cover)

CLOSED FOREST (< 50% Crown Cover)

CONIFEROUS FOREST White Spruce

Code

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

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

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

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

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

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

Black Spruce

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

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

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

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

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

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

Mountain Hemlock

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

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

Deciduous Forest - Closed deciduous, Closed mixed

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

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

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

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

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

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

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

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

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

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

Cottonwood

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

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

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

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

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

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

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

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

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

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

Coniferous Forest White Spruce

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

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

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

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

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

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

Black Spruce

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

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

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

Deciduous Forest Open deciduous, Open mixed

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

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

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

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

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

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

Cottonwood

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

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

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

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

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

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

NON FOREST (<10% Crown Cover)

Saltwater Wetlands

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

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

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

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

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

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

Tall Shrub

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

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

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

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

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

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

Low Shrub

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

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

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

Grass land

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

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

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

Tundra

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

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

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

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

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

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

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

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

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

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

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

Fresh Water Wetlands

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

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

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

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

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

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

NON VEGETATED

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

Barren

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

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

Permanent Snow and Ice

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

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