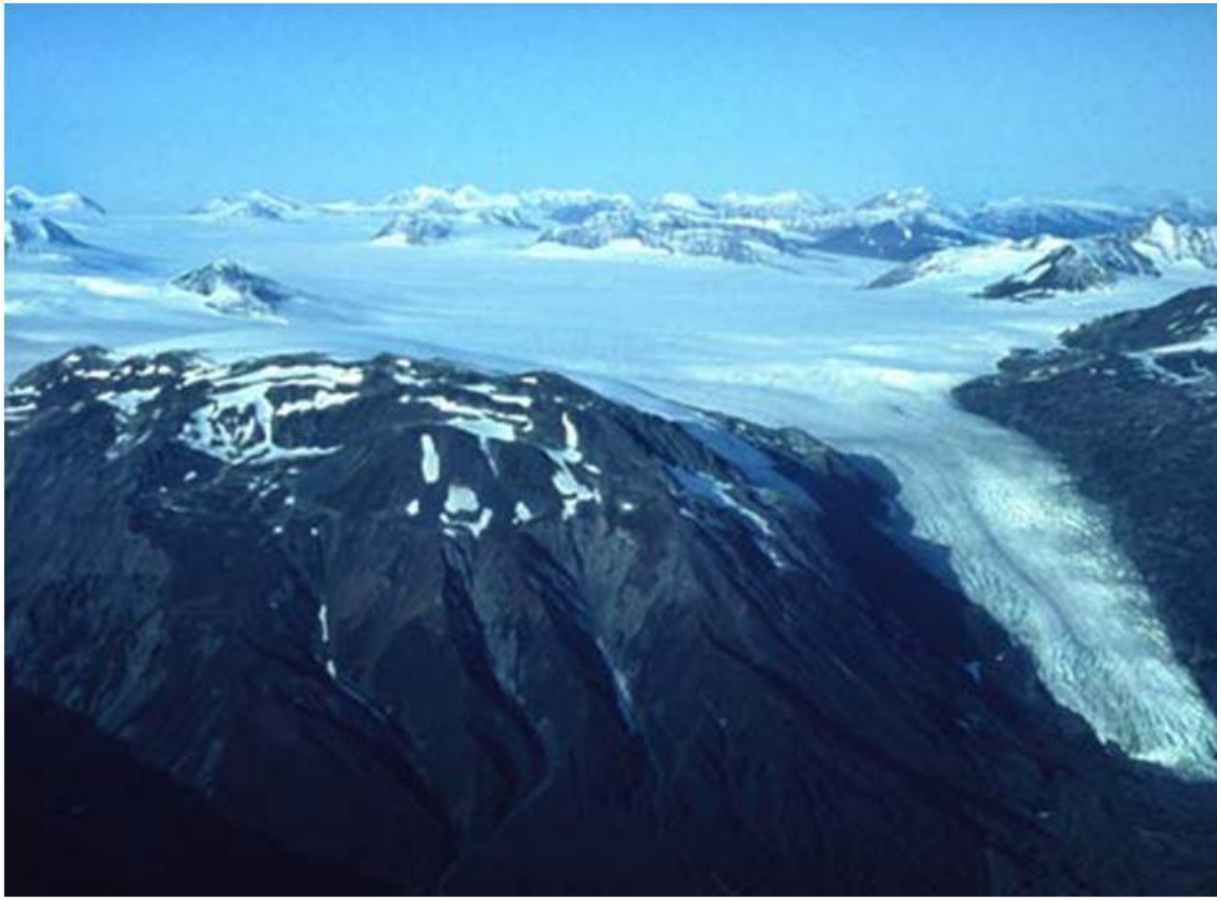
USDA

United States
Department of
Agriculture

Forest
Service
October 2010

Resurrection River Landscape Assessment

Seward Ranger District, Chugach National Forest



Exit Glacier, courtesy of Kenai Fjords National Park.

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Introduction

Purpose

A landscape assessment is a broad-level analysis to provide context and information regarding the effects and impacts that management decisions may have on the ecosystem. Its purpose is to guide land management decisions and provide a means of refining the desired conditions, management prescriptions, and standards and guidelines from the Chugach National Forest Land and Resource Management Plan (USDA Forest Service 2002a; or simply Forest Plan), and current policy and other applicable State and Federal regulations. A landscape assessment is an intermediate step between the Forest Plan and project planning, and serves as a basis for developing project-specific recommendations and determining restoration and monitoring needs within the analysis area.

The structure (including major sections) of this landscape assessment is based on "Ecosystem Analysis at the Watershed Scale: A Federal Guide for Watershed Analysis," a publication produced by a variety of agencies, governments, and organizations (Regional Interagency Executive Committee 1995). The analysis is driven by a set of issues and key questions for a specific watershed. This type of analysis is not a decision-making process, but uses existing data and information to establish the context for project-specific decisions. This document is divided into the following eight sections:

1. Introduction
2. Watershed Characterization
3. Key Issues and Questions
4. Current Conditions
5. Reference Conditions
6. Synthesis and Interpretation
7. Desired Condition, Opportunities, Management Strategies, Data Gaps, Monitoring and Research Needs
8. Recommendations

We discuss the following topics within each of these sections:

- Lands
- Geology, Minerals, and Soils
- Hydrology
- Vegetation and Ecology
- Botany and Weeds
- Fire and Fuels
- Aquatic Species and Habitats
- Terrestrial Species and Habitats
- Heritage
- Recreation

The Analysis Area

The Resurrection River Watershed covers approximately 109,877 acres located in the southwestern portion of the Seward Ranger District on the Chugach National Forest (Figure 1).

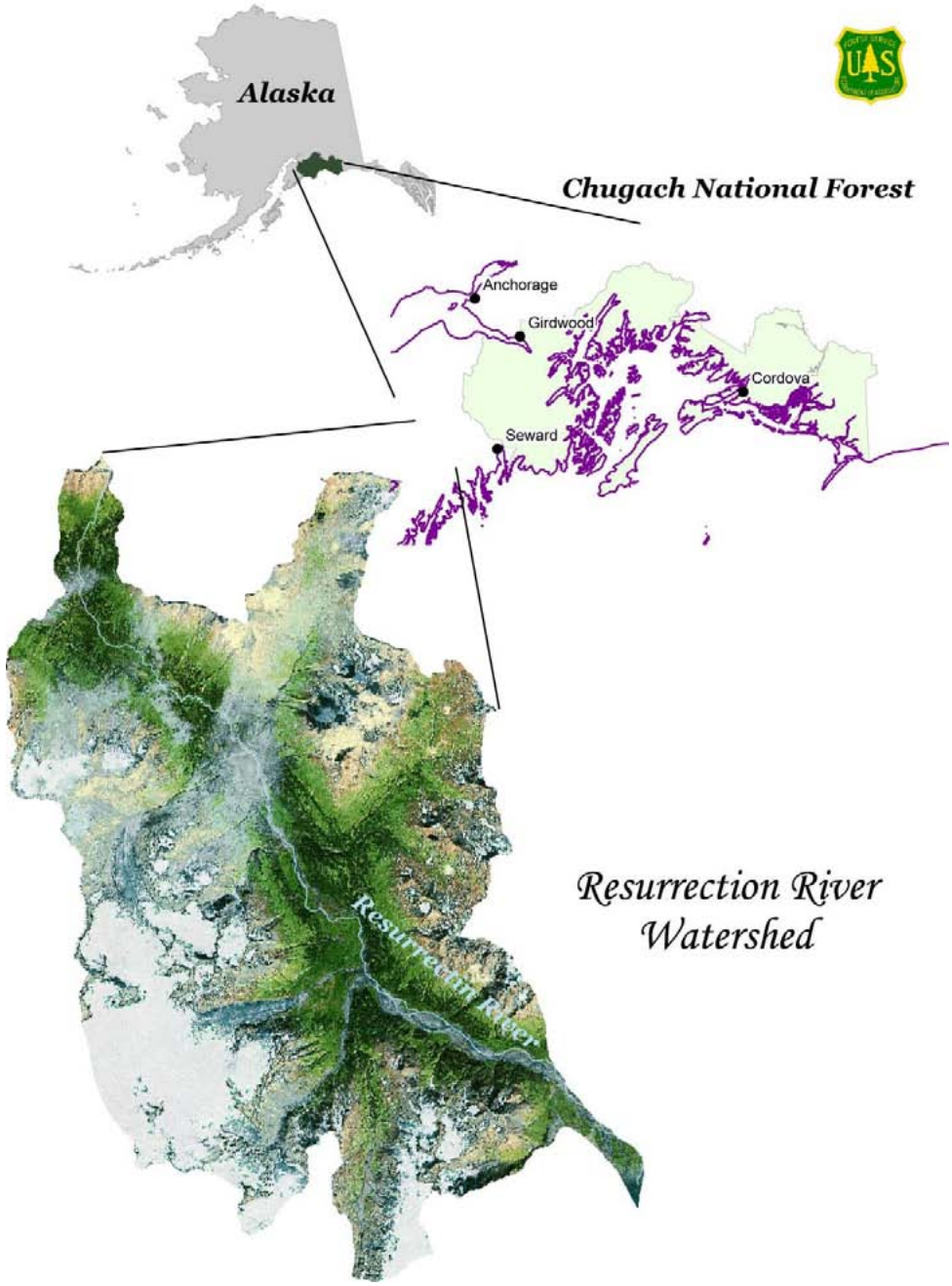

Figure 1. Location of the Resurrection River Watershed

The watershed extends to the mouth of Resurrection River near Seward Alaska, and includes lands owned by the Chugach National Forest, Kenai Fjords National Park, US Fish and Wildlife Service, State of Alaska, Kenai Peninsula Borough, Bureau of Indian Affairs, City of Seward and private land owners (See Figure 2).

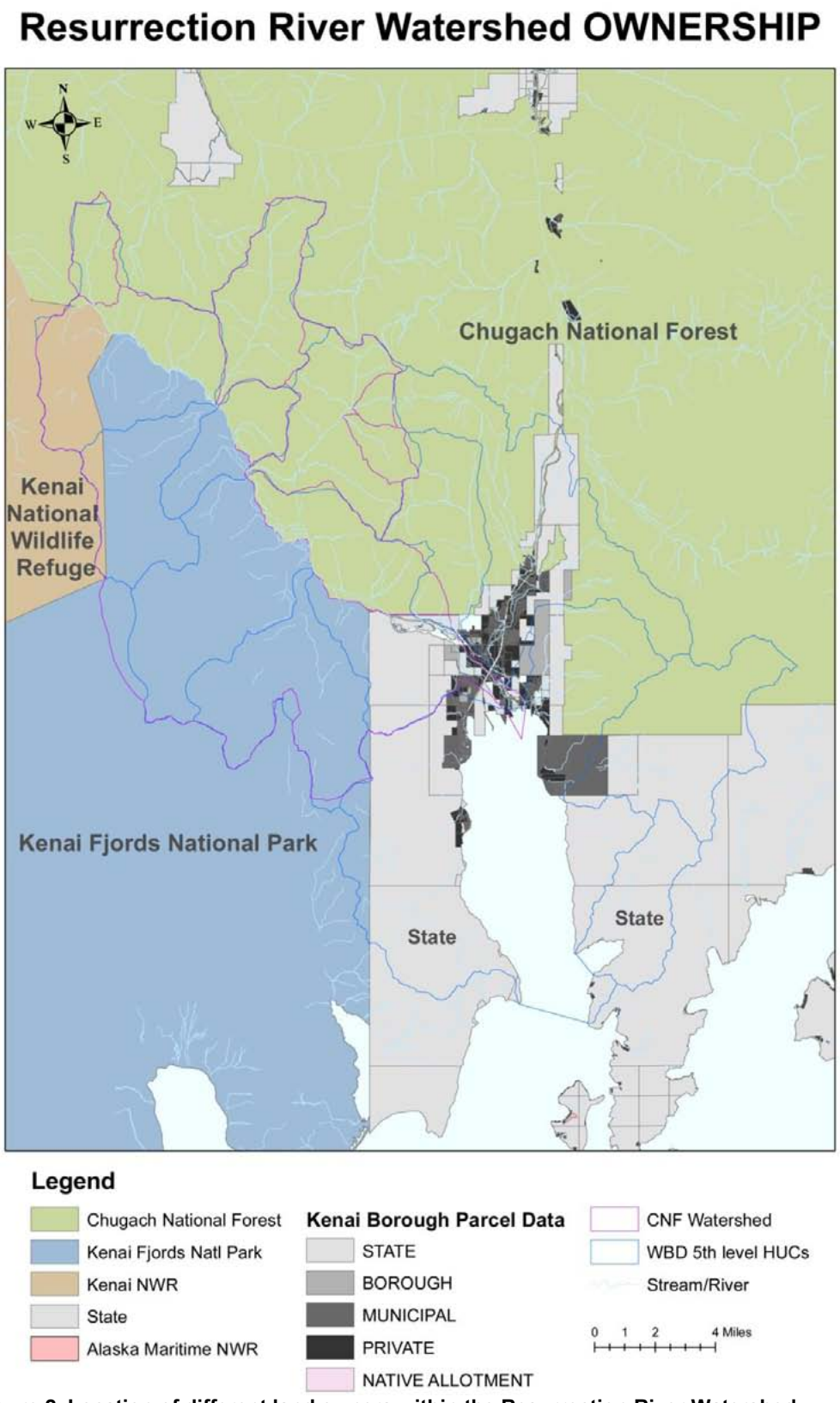

Figure 2. Location of different land owners within the Resurrection River Watershed

Management for Forest Service lands is directed by the Chugach National Forest land management prescriptions as stated in the Chugach National Forest Plan (see Figure 3). Land management objectives for this watershed include 5 different management areas identified within the Chugach National Forest Revised Land and Resource Management Plan. The management areas identified are Brown Bear Core Area; Backcountry; Fish, Wildlife, and Recreation; and Fish and Wildlife Conservation. MA prescriptions are as follows:

- Backcountry - managed to emphasize a variety of recreational opportunities for backcountry activities in natural appearing landscapes.
- Brown Bear Core Area - designed to manage selected landscapes and their associated habitats to meet population objectives for brown bears and to reduce dangerous encounters between humans and brown bears. Ecological processes largely unaffected by human activity, dominate Brown Bear Core Area Management Areas. The following guidelines for vegetation are given in the RLRMP:
    - In landscapes with multiple aspen or birch stands, manage for a mix of structural stages. Conserve the structural diversity of multi-storied stands.
    - Design vegetation management activities, including commercial timber harvest to maintain or enhance brown bear feeding areas and travel corridors and to avoid disturbance to brown bears.
- Fish, Wildlife, & Recreation - managed to provide a variety of habitats for fish and wildlife species and year-round recreational opportunities in both developed and dispersed settings.
- Minerals Management Area - managed for the exploration, development, extraction, and processing of locatable, leasable, and salable minerals.
- Fish and Wildlife Conservation - managed to emphasize the conservation of specific fish and wildlife habitats.(USDA Forest Service 2002)

Table 1. Forest Plan Management Areas

Forest Plan Management Area	Acres
Backcountry Prescription	26,191
Brown Bear Core Area	13,612
Fish, Wildlife & Recreation Prescription	2,830
Mining Claim with Approved Plan of Operations (1998)	642
Transportation/Utility Corridor	84
Fish & Wildlife Conservation Area	80

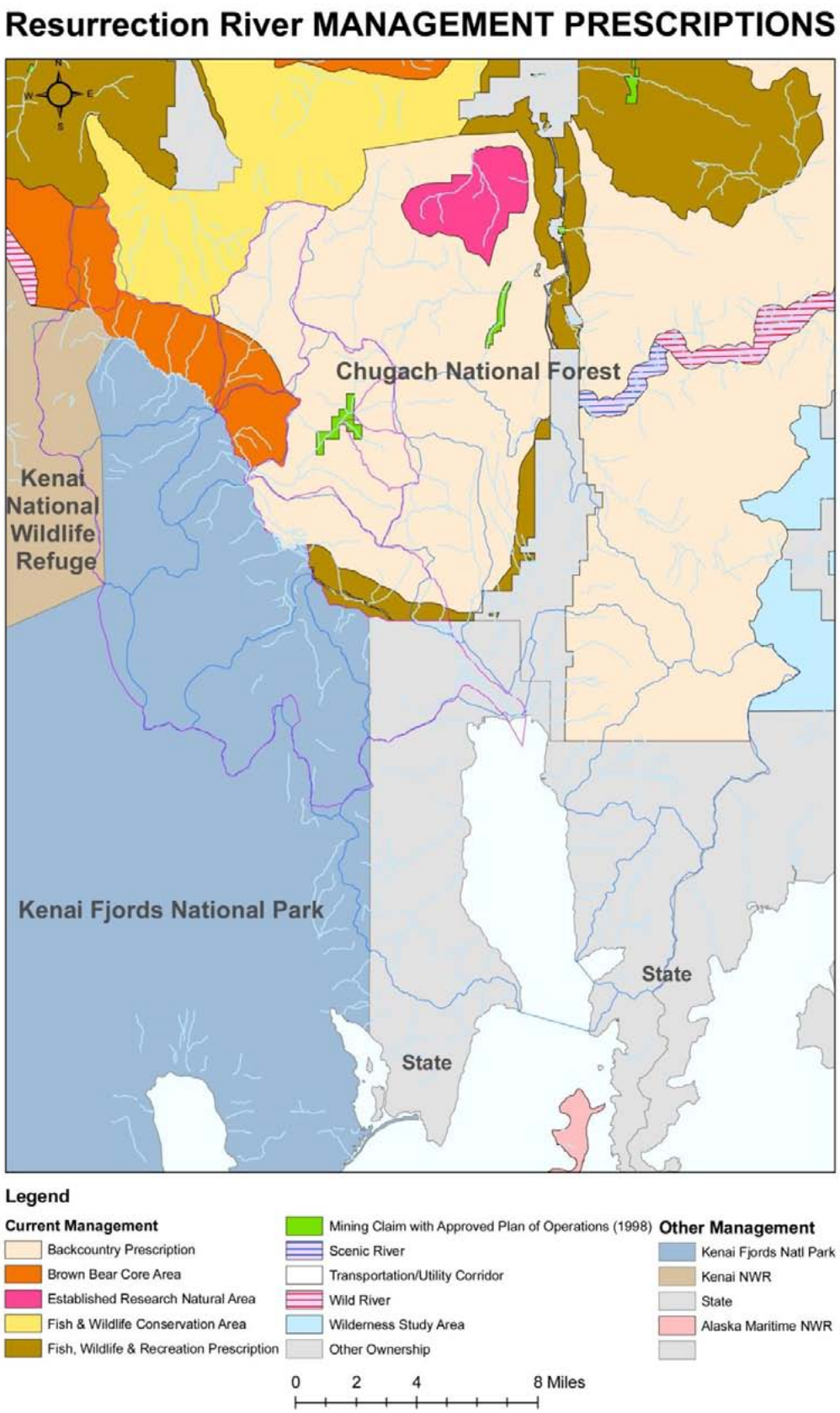

Figure 3. Forest Plan Management Areas

Watershed Characterization

Lands

The landscape analysis area is primarily within federal ownership with the majority of the lands on the east side of Resurrection River owned by the USDA Forest Service and the lands on the west side of Resurrection River owned by the USDI Park Service (Figure 2). For the most part, the lands within the analysis area are not encumbered with easements, licenses, or other partial ownerships. There are some small parcels of privately held lands on the north side of Exit Glacier Road near the City of Seward; however, these parcels are located outside of the analysis area.

Geology Minerals and Soil

Geology

- The 109,877 acre Resurrection River Landscape Assessment Area (RRLA) has predominant steep sloped mountains with no known historic production of locatable minerals
- Areas with better road/trail access will likely receive the most interest for development
- Martin Creek will likely see future placer gold, suction dredge operations

The bedrock of the analysis area is primarily undivided sedimentary rocks of the Cretaceous Valdez Group, a thick sequence of deformed interbedded metasedimentary and metavolcanic rocks. This group is part of a belt of Cretaceous marine rocks 1000 miles long and as much as 60 miles wide that extends along the Gulf of Alaska margin from Chatham Strait in southeastern Alaska to Kodiak and Shumagain Islands in southwestern Alaska. The Valdez Group is part of the Chugach Terrane. These rocks typically include sandstone, siltstone, argillite, slate and phyllite. The entire sequence is folded and deformed and metamorphosed to grades ranging from zeolite to amphibolite facies.

Valdez Group Types: A thick sequence of Late Cretaceous sedimentary rock consisting of sandstone, siltstone, argillite, slate, phyllite, and rare beds of pebbly argillite and is mapped in green as “Sedimentary rocks, undivided, Valdez Group” on the geologic map (Figure 4). Layers are generally a few inches to a few feet thick, but massive sandstone as much as several tens of feet thick is locally present. Valdez Group rocks are the sole bedrock in the analysis area,accounting for 69,531 acres of the assessment area and undoubtedly underlying 25,504 acres mapped as glaciers.

Quaternary deposits: This unit consists of undifferentiated, unconsolidated surficial deposits left by glacial melt water and alluvium from non-glacial streams and is mapped in yellow as “Surficial deposits, undifferentiated” on the geologic map (Figure 4). They are recent deposits composed entirely of clastic material (clay, silt, sand, gravel, and talus). This unit occurs in valley floors and along river and creek bottoms primarily along Resurrection River and also in higher mountain valleys in the northeast portion of the analysis area. Quaternary deposits account for 12,347 acres of the assessment area and also underlie 2,436 acres mapped as water (rivers and streams).

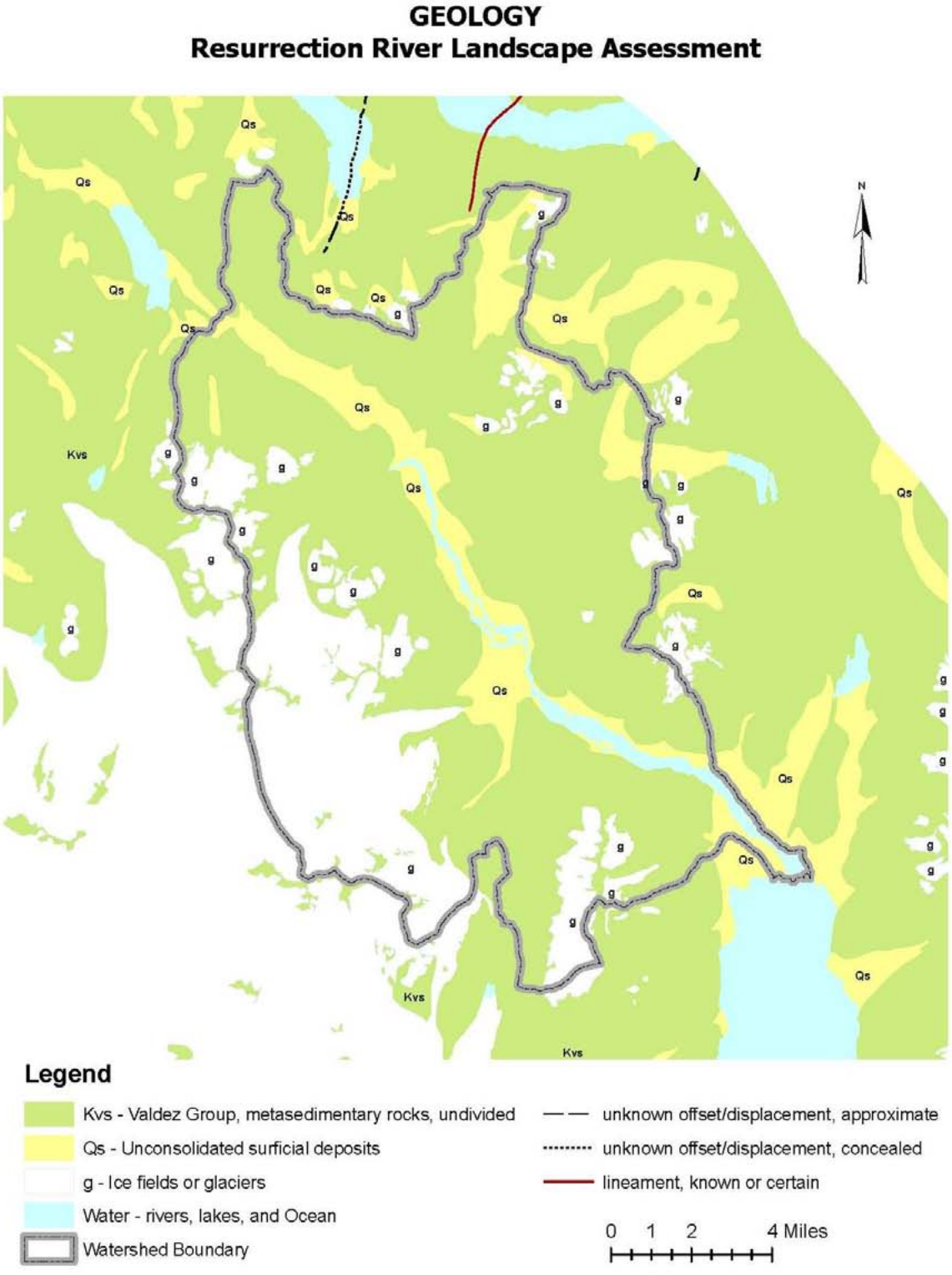

Figure 4. Geologic map of the analysis area

Minerals

Types of minerals administered by the Forest Service includes locatable minerals (36 CFR 228, Subpart A), salable minerals (38 CFR 226, Subpart C), leasable minerals (36 CFR 228, Subpart E), and reserved and outstanding minerals (36 CFR 251.15, FSM 2830). Locatable minerals claimants and operators have a statutory right to develop the mineral resource under the 1872 Mining Law. The disposal of salable minerals is a discretionary action. The Forest Service may determine whether to offer mineral material sales and administer disposal under the salable regulations cited above.

Locatable Minerals – No current plans of operations exist in the analysis area. The submission of additional proposals for mining is difficult or impossible to predict.

The U.S. Geological Survey assessed the mineral resource potential for the Chugach National Forest for the Forest Plan revision (Nelson and Miller 2000). The report focused strictly on metallic mineral resources. It did not cover leasable resources such as coal, oil and gas, or salable resources such as common variety rock, gravel, and sand. The four deposit types evaluated are as follows: 1) Cyprus-type massive sulfide (copper, lead, zinc, gold and silver); 2) Chugach-type low-sulfide gold quartz veins (gold and silver); 3) placer gold; and 4) polymetallic veins (copper, zinc, lead, gold and silver).

Resource Tracts

About 40 percent of the analysis area is administered by the Forest Service and is mapped for Mineral Potential as follows: 4 percent is "Identified as Most favorable, Developable" (4,288 acres, mapped as orange); 36 percent is "Identified as Moderately Favorable" (39,150 acres, mapped as violet); and 60 percent are lands administered by the National Park Service, the U. S. Fish & Wildlife Service; State of Alaska; Kenai Peninsula Borough, or are private lands and are not coded/no data (66,439 acres, mapped as gray) (Figure 5). The Kenai Lake resource tract, the southern tract mapped for mineral potential, is defined by the presence of identified resources of gold from both placer and Chugach-gold deposits (Nelson and Miller, 2000)

Prospects and Occurrences

Locatable Minerals – Jansons et al. (1984) described mineral occurrences on the Chugach National Forest. One lode mineral occurrence was described on Redman Creek and a second lode occurrence was described on Placer Creek on Park Service administered lands but both were considered to have low mineral development potential; their mention is only for demonstrative purposes since these lands are not open to mineral entry. A placer mineral occurrence was also described for a section of Martin Creek. The middle section of the creek was considered as having a high development potential for suction dredging but no known production has been recorded for this mineral occurrence.

Salable Minerals (Mineral Materials, Common Variety Minerals) - According to the geology map several significant Quaternary deposits (sand and gravel) occur within the valley floors of the analysis area. The Bureau of Land Management surveyed mineral material sites on the roaded corridor of the Chugach National Forest (Sherman et al. 1997) for various mineral materials but did not identify any sites along Exit Glacier Road. Additional sand, gravel, and rock needs may be identified in the future for development at the discretion of the authorized officer. Quality rock is in short supply and can be in high demand in and near the assessment area for general fill, road construction, riprap and other construction purposes.

Leasable Minerals - There is low or no potential for oil and gas, and coal deposits in the analysis area.

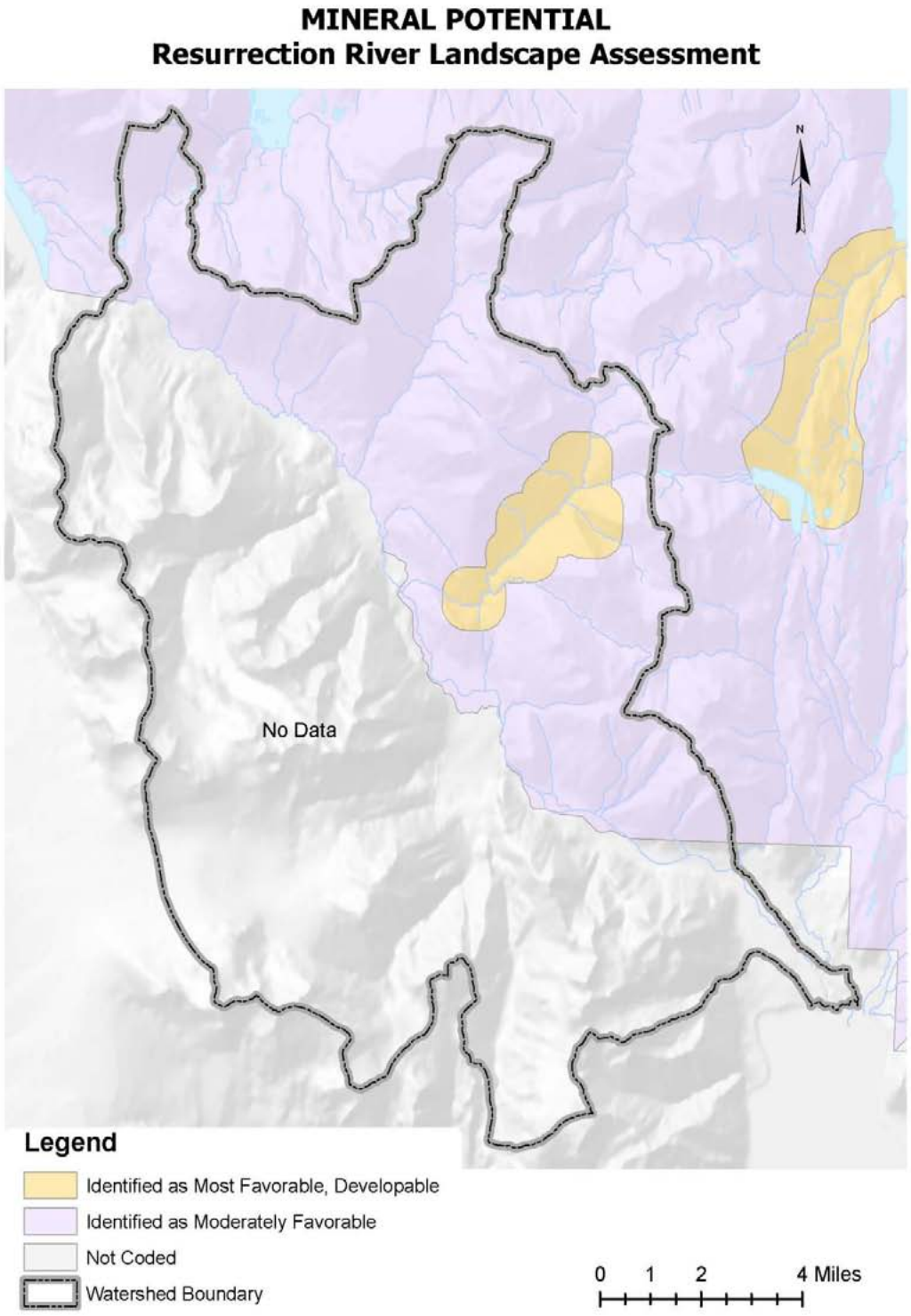

Figure 5. Map of mineral potential within the analysis area

Soils

Geomorphic Process and Landscape History

The Chugach National Forest is dominated by mountains consisting of marine rocks that were uplifted starting in the late Cretaceous Period about 75 million years ago. The most obvious evidence of the uplift is the Eagle River fault which separates the Kenai Mountains from the lowlands on the west side. More recently, numerous igneous intrusions were exposed either through erosion of the overlying rock, or by pushing up through the overlying rock.

Climate is a major contributing factor responsible for the large variation in topography and ecosystems that occur in south-central Alaska. The Chugach National Forest, as part of the coastal region of the north coast of the Gulf of Alaska, receives the vast majority of its weather from the Gulf of Alaska. Storms pick up moisture from the waters warmed by the Japanese Current and move over land, rising orographically over the mountains causing them to drop increasing amounts of precipitation with gains in elevation. The mountains form a barrier to not only the precipitation but also to the moderating influence of maritime temperatures. The landward side of the mountains receive far less precipitation than the ocean side. Also, temperatures on the land side of the mountains are much more extreme, both for high and low temperatures, than on the ocean side.

Glaciations, which started in the Pleistocene Period about 1.6 million years ago and ended about 10,000 years ago, have resulted in a wide variety of glacial carved valleys and mountains throughout the Chugach National Forest. Large outwash plains and marine deltas have also formed from the deposition of sediment resulting from glaciation.

Evidence of glaciation decreases from the east to the west across the Kenai Peninsula and from south to north away from the Gulf of Alaska in response to the gradual reduction in precipitation from the Gulf; to the lee side of the mountains. Storms typically approach south central Alaska from the Gulf of Alaska and bring high amounts of precipitation, which combined with high mountains and cold temperatures, produce heavy snow resulting in glaciers and ice fields. As the precipitation decreases westward across the peninsula and into the interior, the effects of glaciation decrease; such as the presently glaciated, jagged mountains to more rounded mountain tops and U-shaped valleys, and eventually depositional glacial features in the lowlands beyond the mountains.

Hydrology

Climate

The climate of the Resurrection River watershed is primarily influenced by the moisture-laden air of the Gulf of Alaska to the south, although the upper watershed stretches into areas that are influenced by the mountainous climate of the interior Kenai Peninsula. At elevations near sea level at Seward, annual temperatures average about 40 degrees F, average maximum July temperatures reach 59 degrees F, and average minimum January temperatures drop to 20 degrees F (Table 2, Figure 6) (Western Regional Climate Center, 2010). The maritime climate near Seward moderates temperature fluctuations, causing cooler summer temperatures and warmer winter temperatures than interior portions of the Kenai Peninsula or Alaska. Average temperatures, as well as the moderating effect of the maritime climate, decrease with increasing elevation in the watershed and distance from Resurrection Bay.

The watershed lies in a coastal area of the southern Kenai Peninsula, which is subjected to moist air that circulates over Prince William Sound and the Gulf of Alaska to the south and east. As a result, average annual precipitation is high, ranging from about 68 inches in the lower elevations of the watershed to over

100 inches in the higher elevations (Table 2) (Western Regional Climate Center, 2010; USDA Natural Resources Conservation Service, 2010). Precipitation is the heaviest in September and October, and winter months receive more precipitation than summer months. April, May, and June are generally the driest months of the year.

Table 2. Weather station and snow site data for the Resurrection River watershed

Station	Location				Temperature		
	Elevation (ft)	Latitude	Longitude	# of years of data	Average Daily Temp (F)	Average Max July Temp (F)	Average Min Jan Temp (F)
Seward, Alaska [1]	40	60° 07’	149° 27’	57	39.9	62.3	20.3
Seward 9NW, Alaska [1]	490	60° 12’	149° 37’	23	35.9	66.3	11.1
Exit Glacier [2]	400			21	-	-	-
Grouse Creek Divide [2, 3]	700	60° 16’	149° 21’	24	-	-	-
Cooper Lake [2, 3]	1200	60° 23’	149° 42’	24	-	-	-

Station	Ave. Annual Precip (inches)	Average March 1 Snowpack Depth		Average May 1 Snowpack Depth		Peak snowpack of record (by SWE)	
		inches	SWE*	inches	SWE	inches	SWE
Seward, Alaska [1]	68.1	-	-	-	-	-	-
Seward 9NW, Alaska [1]	71.8	-	-	-	-	-	-
Exit Glacier [2]	-	50	15.2	30	12.3	89	31.2
Grouse Creek Divide [2, 3]	60.0	52	15.7	44	16.6	85	36
Cooper Lake [2, 3]	38.4	47	13.7	33	12.0	71	29.3

[1] Weather station data (WRCC, 2010); [2] Snow course data (USDA NRCS, 2010)
[3] SNOTEL Site (USDA NRCS, 2010); * SWE=Snow water equivalent

Snow generally falls at all elevations of the watershed between the months of October and April. Winter rain is common in the lower elevations of the watershed. Snowfall and snowpack in the Resurrection River watershed increase dramatically with elevation. The lower elevations of the watershed near Seward receive about 83 inches of snow annually, with snowpack depths generally averaging less than 10 inches. Higher elevations in the watershed receive considerably more snow, with average maximum annual snowpacks over 50 inches (USDA Natural Resources Conservation Service, 2010; Western Regional Climate Center, 2010) (Table 2). In the low elevations, snowfall accounts for less than 25 percent of the total annual precipitation. In the higher elevations, snowfall accounts for over 50 percent of the total annual precipitation.

Watershed Morphology

The analysis area for this landscape assessment is defined by the Resurrection River Watershed Association, as delineated by the Chugach National Forest (Figure 1). The Resurrection River Watershed Association covers 109,877 acres (171.7 square miles), with a length of about 23 miles. The eastern half of the Watershed Association lies on National Forest System lands, and the western half lies primarily on National Park Service lands, with the center of the Resurrection River channel defining the boundary (Figure 6). A total of 43,453 acres (40 percent) of the Watershed Association lie on National Forest System lands within the Chugach National Forest boundary. Although Box Canyon Creek flows into Resurrection River, it is not included within the analysis area because the Watershed Association boundary was delineated based on historic mapping of Box Canyon Creek flowing into Salmon Creek to

the east. The southern portion of the Resurrection River Watershed Association extends along Resurrection River to its mouth in Resurrection Bay at Seward. Although Salmon Creek also flows into the head of Resurrection Bay, it does not join Resurrection River and is not included as part of the analysis area.

The analysis area comprises the northwestern half of the "Resurrection River" 5th-level watershed (Hydrologic Unit Code 1902020206), as delineated in the recently developed state-wide Watershed Boundary Dataset (WBD) (Figure 6). This 223,810-acre (350-square mile) 5th-level watershed includes everything that flows into Resurrection Bay, including Resurrection River, Salmon Creek, and the frontal watersheds of Resurrection Bay. Although the WBD was developed using national standards for watershed delineation and is known to be more spatially accurate than the Watershed Association boundaries, this analysis is based on the Resurrection River Watershed Association in order to align with Forest Plan administrative boundaries that were also based on Watershed Associations. It is intended that the Chugach National Forest will ultimately adopt the WBD in the future to define its watersheds and future planning boundaries.

The Resurrection River watershed drains to the southeast into Resurrection Bay of the Gulf of Alaska. Elevations within the watershed range from sea level to 5710 feet at Mount Ascension. Based on current National Hydrography Dataset (NHD) mapping, glaciers cover about 25,850 acres, or 24 percent of the watershed. Approximately 92 percent of the glaciers in the watershed lie on the western half of the watershed in Kenai Fjords National Park, primarily associated with the Harding Icefield and its associated glaciers that descend to the valley floor. Although Resurrection River and some of its tributaries are highly influenced by glaciers as a result of the large glacial component in the watershed, most of the streams in the watershed on National Forest System lands do not have large glacial components.

Resurrection River lies within a wide, U-shaped glacially carved valley with a relatively flat valley floor and steep valley sides with 4000 to 5000 feet of vertical relief. Tributaries to the Resurrection River include small hanging valleys such as Martin Creek and Boulder Creek, where smaller glacially carved valleys are perched higher than the main valley of Resurrection River. The lower portions of these tributary streams are generally incised into V-shaped canyons or gorges as a result of post-glacial fluvial erosion.

No sizeable lakes are located within the Resurrection River Watershed Association. The only lakes mapped by Chugach National Forest data or NHD are scattered small ponds less than 10 acres in size and totaling a very small percentage of the watershed. The Watershed Association does include 225 acres of NHD-mapped sea/ocean at the mouth of Resurrection River.

Streams

A total of 194 miles of stream channel lie within the Resurrection River Watershed Association, as mapped by the National Hydrography Dataset (NHD). This represents a stream density of 1.13 stream miles per square mile. Resurrection River is the largest and primary river in the watershed, flowing 27.6 miles from the head of the watershed near Upper Russian Lake to the mouth at Resurrection Bay and comprising 57.7 miles of stream channel, including all of its braids and side channels. The center of the Resurrection River channel represents the boundary between National Forest and National Park Service lands. As mapped by NHD and excluding the channels of the Resurrection River itself, a total of 70.2 miles of streams lie on National Forest System lands in the east side of the watershed, and a total of 66.5 miles of streams lie on non-National Forest System lands on the west side of the watershed. Boulder Creek and Martin Creek are the major tributaries on USFS lands in the east side of the watershed.

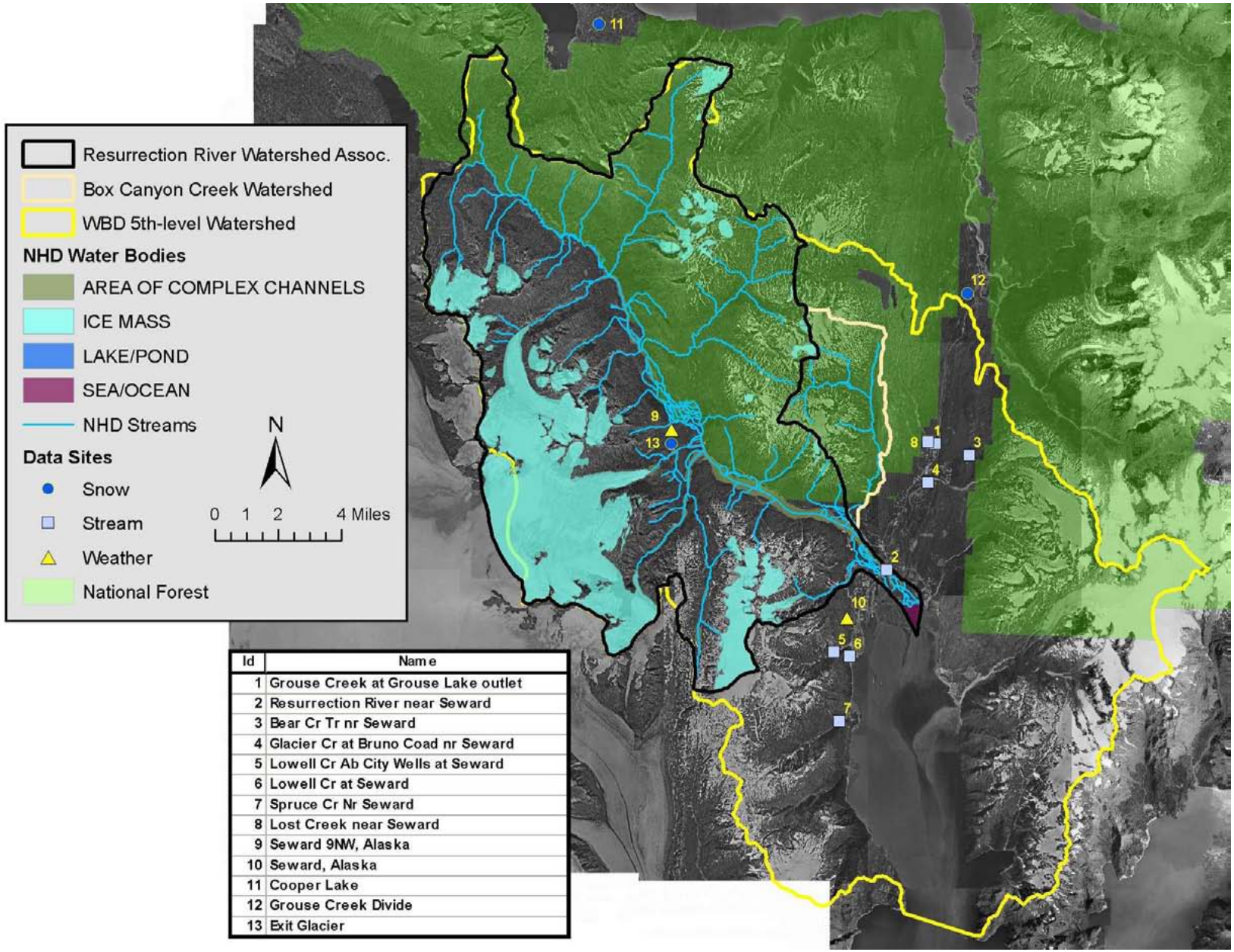

Figure 6. Watersheds and data collection sites in the Resurrection River watershed

Resurrection River and streams on the east side of the watershed were mapped and assigned channel types by the Chugach National Forest. Channel types are based on the Tongass National Forest Channel Type User Guide (USDA Forest Service, Alaska Region, 1992) (Figure 7). Chugach National Forest stream channel mapping does not align perfectly with NHD mapping. Although NHD is likely more accurate, the USFS-mapped stream channels are still used because numerous attributes are associated with these spatial stream data. Stream mapping on the west side of the watershed is based only on NHD mapping, and no channel types are assigned to those channels.

The upper 4.3 miles of Resurrection River varies from a "High Gradient Contained" to a "Moderate Gradient Mixed Control" to a "Palustrine" channel as it flows down into the valley floor. The lower 23.9 miles of the length of Resurrection River is a "Glacial Outwash" channel, generally with multiple braided channels and wide outwash deposits. Excluding Resurrection River, 64.0 miles of streams are mapped and classified on USFS lands on the east side of the watershed. 60 percent of these streams are classified as "High Gradient Contained" channels, or headwater streams draining steep hillsides. About 12.8 percent of the channels are classified as "Moderate Gradient Contained," 10.3 percent are classified as "Moderate Gradient Mixed Control," and 6.5 percent are classified as "Glacial Outwash." "Alluvial Fan" channels comprise 4.6 percent of the streams where high gradient streams encounter lower gradient valleys.

The 27.6-mile length of Resurrection River varies greatly from the headwaters to the mouth (Figure 8). In its first 4.3 miles, Resurrection River is a small, high gradient stream in the headwaters of the watershed. As it progresses downstream over the next 7.1 miles, it gains flow from various tributaries and becomes a single-channel meandering stream in the upper Resurrection River valley. This portion of the Resurrection River is characterized by high sinuosity, a low gradient averaging about 0.4 percent, and wide, vegetated floodplains.

As glacially influenced tributaries join Resurrection River over the next 7.5 miles, primarily from glaciers draining the Harding Icefield on the west side of the watershed, sediment loads and peak flows increase in the Resurrection River, resulting in a more dynamic, multi-channel morphology. New channels are commonly cut through forests in this area as sediment and wood deposition control the location of the main channel. The average gradient of this section is about 0.4 percent.

The next 8 miles of Resurrection River, from the confluence with the Exit Glacier outflow to the mouth at Resurrection Bay, is a wide, braided glacial outwash channel. This portion of Resurrection Creek is highly dynamic and carries high sediment loads from glacial sources. The channel substrate is primarily gravel and cobbles, the gradient is fairly constant at about 0.5 percent, and the braided channel ranges from 1000 to 2500 feet in width.

The final 1.5 miles of the Resurrection River, downstream of the Seward Highway Bridge, forms a multi-channel delta into Resurrection Bay. Dynamic channels diverge in this low gradient depositional area. Salmon Creek joins the Resurrection River corridor at this location, but remains physically separated from the Resurrection River itself by a constructed and maintained gravel berm.

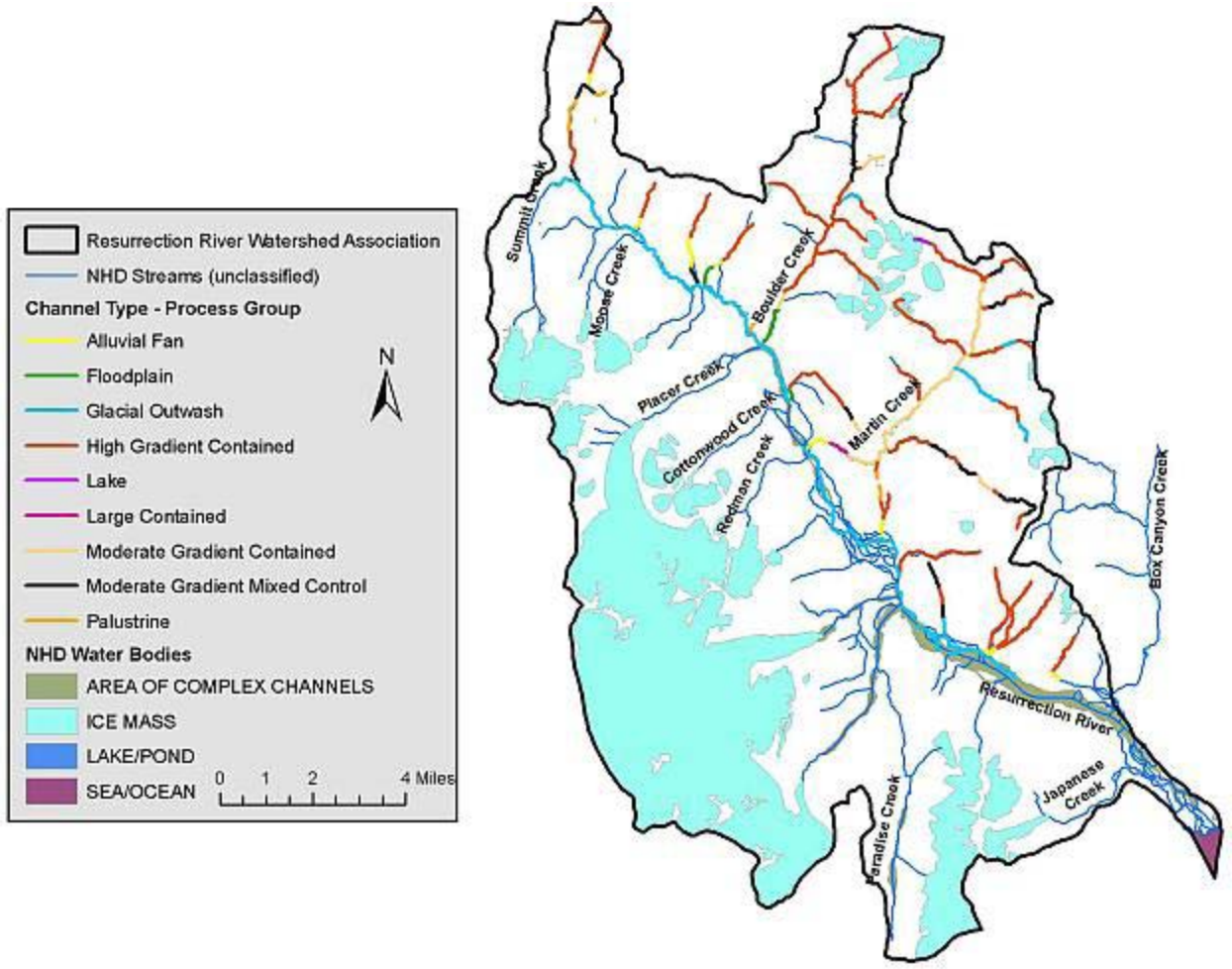

Figure 7. Stream channel type process groups in the Resurrection River watershed. Data from USDA Forest Service.

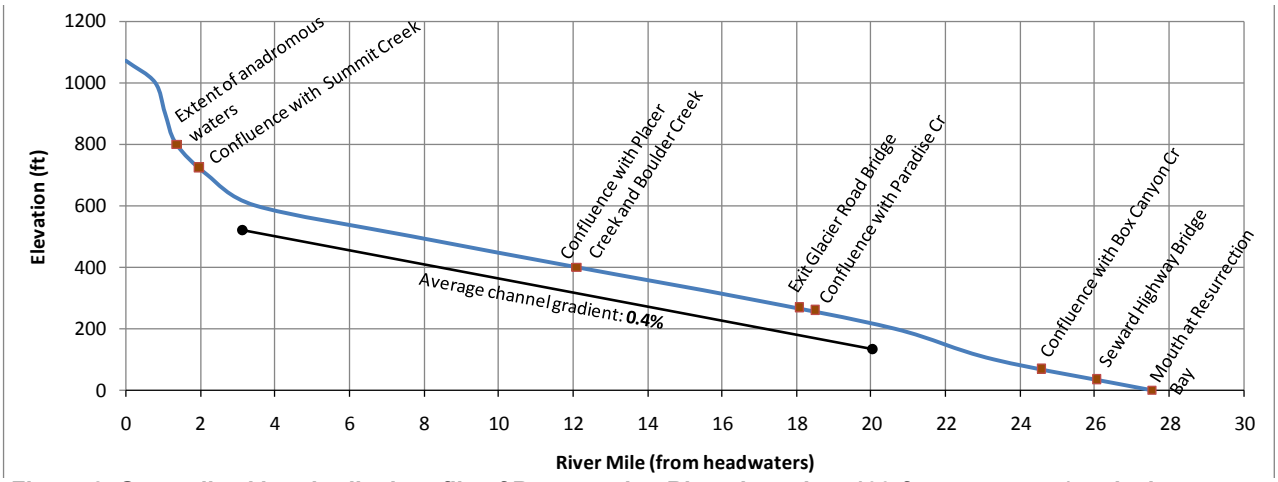

Figure 8. Generalized longitudinal profile of Resurrection River, based on 100-foot contours (vertical exaggeration 50x)

Wetlands

Wetlands are mapped for 70 percent of the Resurrection River Watershed Association through the US Fish and Wildlife Service National Wetland Inventory. These mapped wetlands cover 5,061 acres, or 4.6 percent of the Resurrection River watershed (Figure 9), primarily in the valley floor along the Resurrection River corridor. The mapped wetlands include 2,683 acres of palustrine wetlands (areas associated with swamps, bogs, ponds, beaver ponds, and floodplains), 2,043 acres of riverine wetlands associated with the Resurrection River, and 335 acres of estuarine wetlands at the mouth of the river. Much of the watershed area that contains no wetland data is covered by glaciers and icefields, although it also includes a 2.5-mile long portion of the Resurrection River corridor, where it is likely that palustrine and riverine wetlands are present.

Wetlands were also mapped in 2006 in the Seward area as part of the Seward Wetland Mapping Project conducted through the Kenai Watershed Forum and the Kenai Peninsula Borough (Kenai Watershed Forum, 2007). This project mapped an area of 24,600 acres, only on non-National Forest system lands. This local mapping effort likely produced more detail and better accuracy than the National Wetland Inventory mapping.

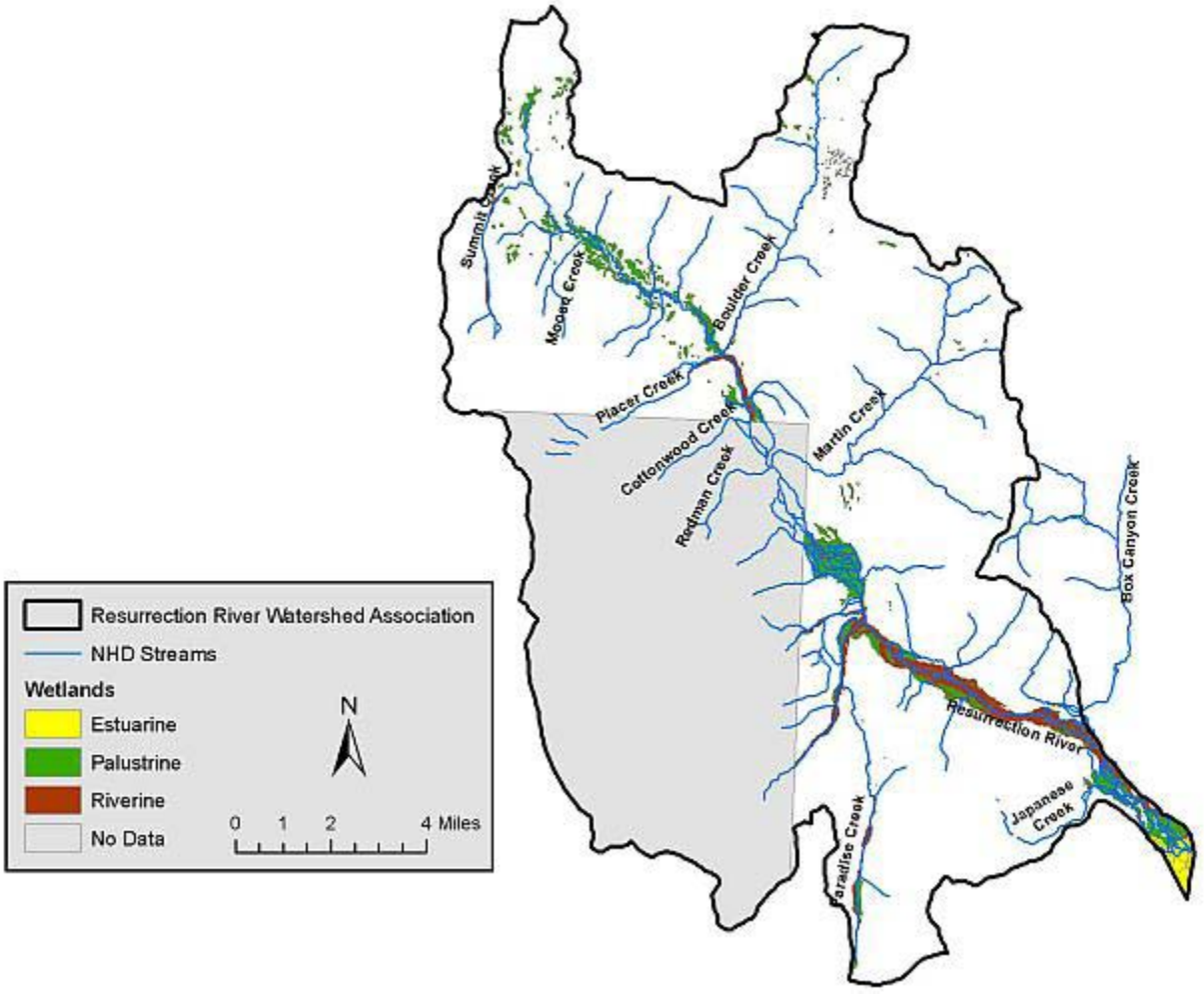

Figure 9. Wetland classification for the Resurrection River watershed. Data from US Fish and Wildlife Service wetland mapping (1997).

Streamflows

Streamflows in the Resurrection River watershed are controlled by early summer snowmelt runoff, mid-summer glacial melt runoff, and rainfall runoff typically from fall rainstorms. With 24 percent of its watershed covered by glaciers, glacial melt runoff is the primary control on streamflows in the Resurrection River itself. Rainfall runoff creates the most dramatic peak flows in the lower valley area around Seward, often causing flooding in the smaller non-glacial tributaries. The highest magnitude floods in Resurrection River occur when intense rainfall flooding occurs during periods of already high glacial melt.

Historical streamflow data from the US Geological Survey exist for 8 sites on rivers and streams in the vicinity of the Resurrection River watershed (Table 3, Figure 6) (US Geological Survey, 2010). Seven of these sites are outside of the Resurrection River Watershed Association, but within 4 miles of the watershed boundary. Four of these sites have very short periods of record. Only one of these sites is currently in operation as a real-time stream gauge.

Table 3. Streamflow data summary for the Seward area

USGS Station Name	USGS Station Number	Type of Data	Years of Data	Latitude (NAD27)	Longitude (NAD27)	Drainage Area (sq mi)
Grouse C At Grouse Lk Outlet Nr Seward AK	15237730	Daily, Peak	1997 - 2010	60°11'54"	149°22'24"	6.22
Resurrection R at Seward AK	15237700	Daily, Peak	1964-1968	60°08'30"	149°25'00"	169
Bear C Tr Nr Seward AK	15237800	Daily, Peak	1966-1968	60°11'35"	149°20'20"	1.63
Glacier C at Bruno Road Nr Seward AK	15237900	Peak, gauge ht	1986 - 2007	60°10'49"	149°22'46"	n/a
Lowell C Ab City Wells At Seward AK	1523849020	Daily, Peak	1993 - 1995	60°05'59"	149°27'51"	3.73
Lowell C At Seward AK	15238500	Daily, Peak	1965 - 1993	60°05'55"	149°26'35"	4.02
Spruce C Nr Seward AK	15238600	Daily, Peak	1967 - 2008	60°04'10"	149°27'08"	9.26
Lost Creek Near Seward AK	15238000	Peak	1949 - 1987	60°11'54"	149°22'42"	8.42

USGS Station Name	# Years of peak flow data	Extreme instantaneous peak flow (cfs)	Estimated 2-year flow (Q2) (cfs) [1]	Estimated 10-year flow (Q10) (cfs) [1]	# Years of daily flow data	Peak average daily flow (cfs)
Grouse C At Grouse Lk Outlet Nr Seward AK	12	901	-	-	14	56
Resurrection R at Seward AK	4	19,000	-	-	4	8,900
Bear C Tr Nr Seward AK	2	134	-	-	2	43
Glacier C at Bruno Road Nr Seward AK	15	4,200	-	-	-	-
Lowell C Ab City Wells At Seward AK	2	1,810	-	-	2	555
Lowell C At Seward AK	5	1,200	-	-	6	160
Spruce C Nr Seward AK	42	13,600 [2]	1,620 cfs (175cfs/sqmi)	2,720 cfs (294cfs/sqmi)	32	302
Lost Creek Near Seward AK	13	14,000 [2]	342 cfs (41 cfs/sqmi)	819 cfs (97 cfs/sqmi)	-	-

[1] Estimated flow statistics from Curran et al. (2003).
[2] Peak flows from Oct 1986 flood, may be result of debris jam breakout flood. Next highest flood peak is 3640 cfs for Spruce Creek and 920 cfs for Lost Creek.

Flow regimes for streams in the watershed vary by stream type. Resurrection River is a large glacial river that is controlled primarily by glacial melt, where peak flows generally occur in the late summer, during

the peak of glacial melting (Figure 10). A combination of high flows from glacial melting and runoff from fall rainstorms can cause flooding, which is most common during the months of August, September, and October. Winter flows are generally low because glacial melting stops with freezing temperatures at higher elevations.

Non-glacial tributaries to Resurrection River, including many of the streams near Seward, are primarily controlled by rainfall runoff during the late summer, fall, and winter. Summer snowmelt runoff generally causes an initial peak flow in June (Figure 10). Fall rainstorms can cause dramatic fluctuations in flow, as well as very high peak flows per square mile of drainage area. Because of the low elevations of many of these drainages, they can also respond to winter rainfall with high flow magnitudes.

Peak flow magnitudes in the Resurrection River watershed and in the Seward area are very high per square mile of drainage area. US Geological flow data show the 10-year flood magnitude varying from about 100 to 300 cfs per square mile of drainage area in streams near Seward (Curran et al., 2003). Because of its larger drainage area, Resurrection River likely experiences much lower unit discharges per square mile than its tributaries. Several streams in the Seward area are known to experience extreme flood events as a result of debris jam breakout floods caused when a landslide or avalanche temporarily dams a stream in a narrow confined canyon. This has occurred on Box Canyon Creek, and may also be the cause of the extreme peak flows measured on Spruce Creek, Lost Creek, Japanese Creek, and Godwin Creek during the October 1986 floods. The largest peak flow resulting from a debris dam outburst flood during the October 1986 flood was estimated to be 2,200 cfs per square mile on Godwin Creek south of Seward, transporting boulders as large as 8 feet in diameter (Lamke and Bigelow, 1988). The largest flood not caused by a debris dam release during the 1986 flood was 1,020 cfs per square mile on Rudolph Creek (Jones and Zenone, 1988).

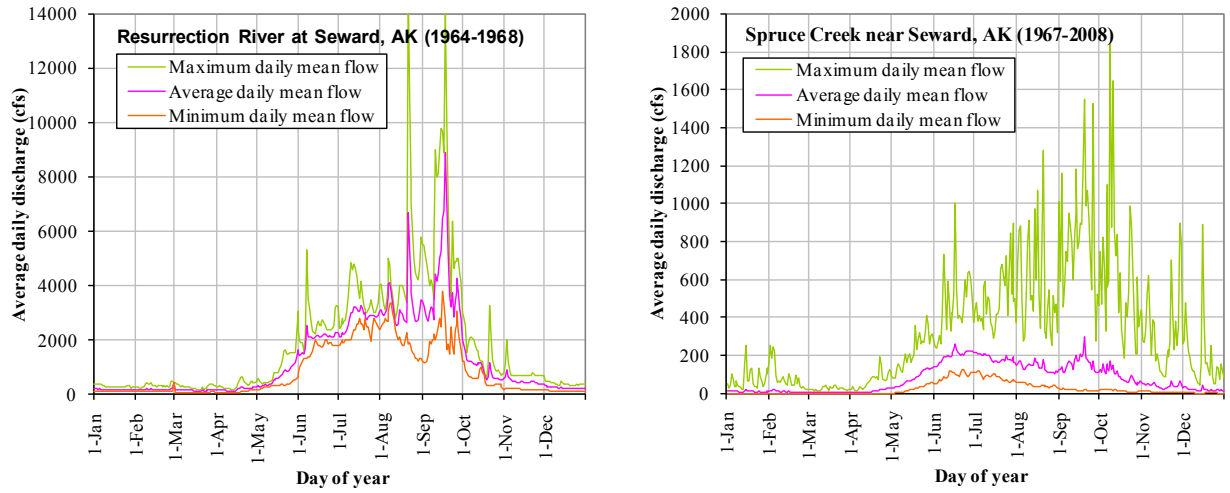

Figure 10. Average daily streamflows for Resurrection River at Seward (left) and Spruce Creek near Seward, AK (right). Data from US Geological Survey (2010).

Water Quality

Water quality data are limited for the Resurrection River watershed. Water quality data were collected by the US Geological Survey on the Resurrection River near Seward on 44 dates between 1952 and 1995 (US Geological Survey, 2010). These data meet Alaska State standards (Alaska Department of Environmental Conservation, 2009) with the exception of one low pH reading.

Because of the limited development in the analysis area, water quality is generally unimpaired. The presence of glaciers in the watershed causes moderate to very high turbidities in Resurrection River and many of its tributaries. Turbidities from glacial melting increase throughout the summer as the rate of glacial melting increases. US Geological Survey data from 1959 to 1995 showed suspended sediment loads of 5 to 1120 mg/L (2 to 23,600 tons/day). Non-glacial tributary streams normally have low turbidities, but because of the steep and rugged topography in the area, high flows can be associated with high sediment transport and moderate to high turbidities.

No streams in the watershed are listed on the 303(d) list of impaired water bodies, and sources of water pollutants are limited. Sources of human-caused sedimentation are limited on Forest Service lands in the watershed, and those that do exist have very little effect on water quality because of the naturally high levels of sediment in Resurrection River and many of its tributaries. Potential sources of water quality impairment in the lower portion of the watershed include hydrocarbons entering Resurrection River from the Seward Highway and Exit Glacier Roads, and on non-National Forest system lands, residential and industrial pollutants from the Seward area.

Vegetation and Ecology

At the landscape level vegetative patterns in the watershed have been affected by past glaciations, floods, insects, diseases, and human development. All successional stages are present in this watershed. Early seral species such as cottonwood are present on recently de-glaciated sites and river bottoms, spruce is present in many places as a mid seral species, and mountain hemlock is present as a climax species.

Within each stand, variation occurs. Stands that are denoted as early seral stands probably have a component of mid seral and climax species in the understory. Trees found in the understory of early seral stands are most likely species that are more shade tolerant than the species found in the overstory. As older and less vigorous trees in the overstory succumb to various causes of mortality including wind throw, insects, and diseases, the overstory is eventually replaced with later seral species.

Various disturbance agents are driving forest succession in this watershed. Glaciers have scoured sites and prepared them for primary succession, which is “succession…on sites that have not previously borne vegetation” (Helms 1998). Large plants present on recently de-glaciated sites in this watershed would include alder, willow, and cottonwood.

Minor disturbances, including insect and disease related mortality, competition based mortality, windthrow, and floods are drivers of secondary succession in this watershed. These minor disturbances create gaps in the canopy which allow shade tolerant trees persisting in the understory to be promoted into the overstory.

Topography is also a factor in affecting vegetation distribution. Rock and ice cap the peaks of mountains in this watershed. Below the rock and ice, alpine vegetation of graminoids and forbs is noted. A shrubby transition zone, which consists of alder and willow exists below the alpine zone and immediately above the forested area of the watershed. A mixture of trees is found in the forested area of the landscape, including white spruce, Lutz spruce, Sitka spruce, mountain hemlock, aspen, birch, and cottonwood (See Figure 13).Figure 11 displays forest plan management areas that direct potential vegetation management opportunities.

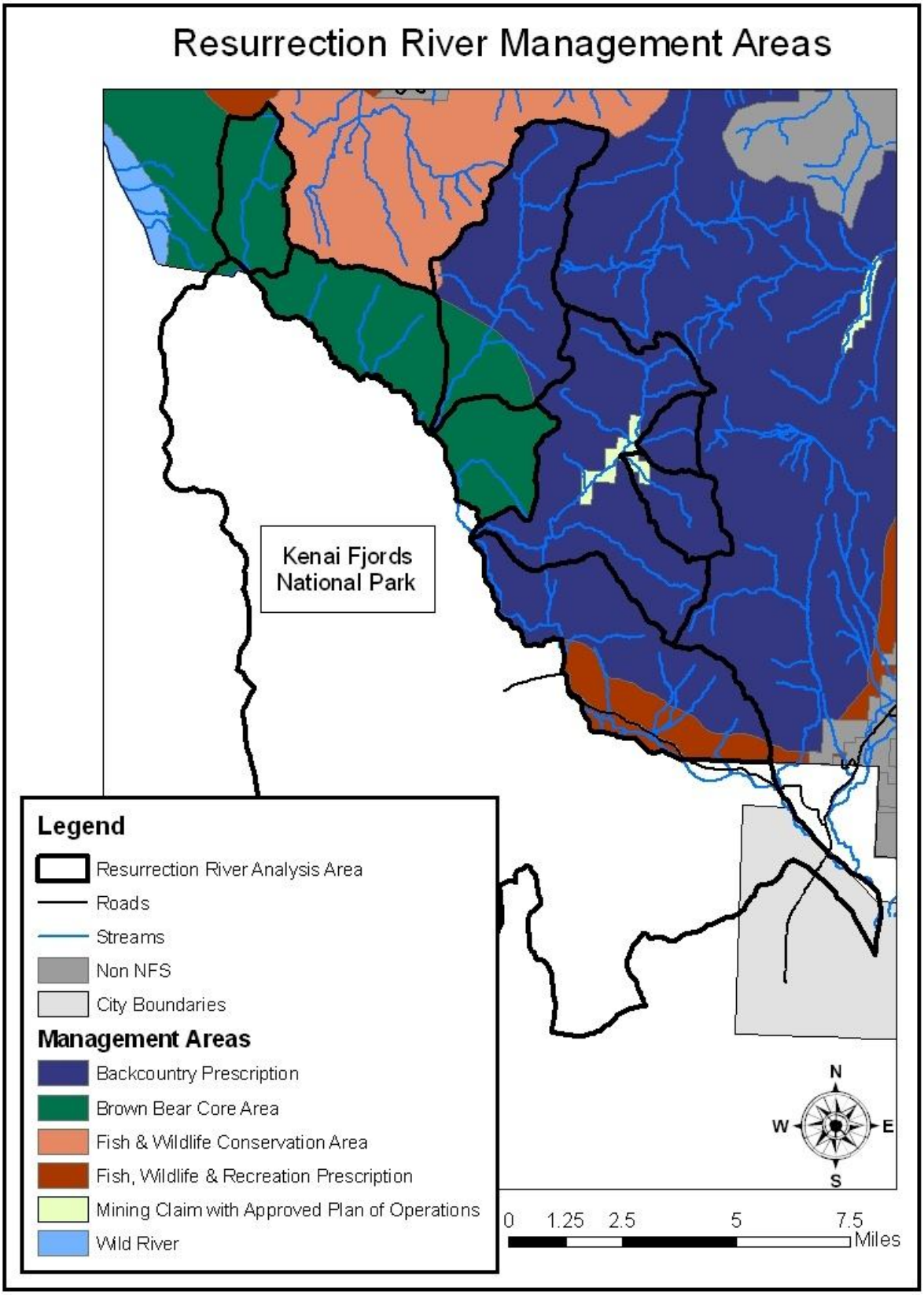

Figure 11. This map shows the management areas and their extent within the Resurrection River Watershed on the Chugach National Forest.

Botany and Weeds

Non-native Plants

Non-native plants within the Resurrection River watershed occur in areas of human disturbance such as along roads, trails and facilities (See Figure 18). Natural, undisturbed ecosystems are typically free of non-native plants.

Sensitive and Rare Plants

There is only one sighting of a Region 10 Sensitive plant species within the Resurrection River watershed. This may be a data gap as very little of the watershed has been surveyed for sensitive plant species (See Figure 19).

Fire and Fuels

The Kenai Peninsula is a transitional zone between boreal forests merging with the coastal rain forest. Sitka spruce thrives in the near coastal zone where climatic conditions limit the frequency and intensity of naturally occurring fires. Mountain hemlock is considered to occur as a subalpine forest, which usually burns infrequently; however, fire is the primary large-scale disturbance agent in these forests (Agee, 1989). White spruce is adapted to a wide range of ecosystems and climatic conditions and has a transcontinental range across Alaska where it overlaps with Sitka spruce near sea level (Burns and Honkala, 1990). Fire has played an integral role in the evolution and maintenance of the flora and fauna of northern circumpolar forest habitats. Throughout the range of white spruce, fire has been an important, sometimes dominant factor in forest dynamics. White spruce is probably more susceptible to destruction by fire than any other tree in Alaska (Lutz, 1953).

Fire has historically been present in this century in the Kenai Mountains but whether fire is the important disturbance process creating structural and landscape diversity within this ecosystem is unknown. There are three distinct areas of fire frequency: prehistoric (pre-1740), settlement (1741- 1913) and post-settlement (1914 to present). Forests on the peninsula had not sustained timber harvest prior to 1740. Uncut forests provide a rare opportunity to discern the natural dynamics of vegetation in an expanding landscape becoming dominated by both human and insect disturbances.

Aquatic Species and Habitats

The Resurrection River Watershed contains 194 miles of stream, including 44.9 miles of class 1 stream producing anadromous fish and stream habitat, 17.7 miles of class 2 streams which contain resident fish species, 40.4 miles of class 3 headwater non-fish bearing streams, 18.6 miles of complex channel or artificial paths, and 72.4 miles of unclassified streams, on NPS land (Figure 12).

All five species of Pacific salmon; Chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), sockeye (*Oncorhynchus nerka*), pink (*Oncorhynchus gorbuscha*), and chum (*Oncorhynchus keta*) are indigenous to the Resurrection River Watershed and contribute to the Resurrection Bay sport and commercial fisheries. Eulachon (*Thaleichthys pacificus*) migrate into Resurrection River to spawn in the early spring. Dolly Varden char (*Salvelinius malma*) are also present in the watershed.

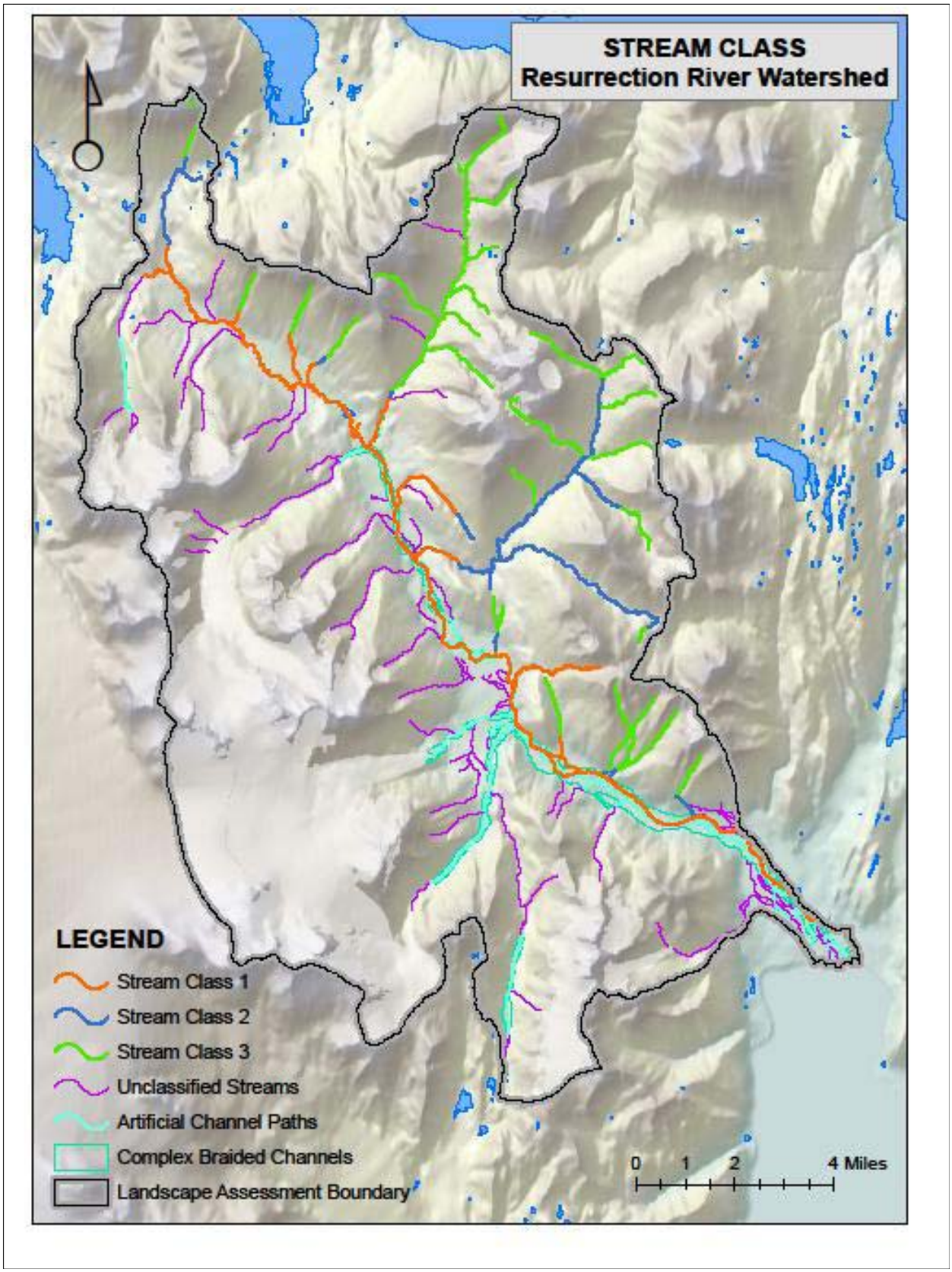

Figure 12. Fish Habitat stream classification in the Resurrection River Watershed (data from Forest Service; classification system from USDA Forest Service [2001])

Table 4. Fish habitat stream classification (USDA Forest Service 2001) in the Resurrection River Watershed

Stream Class	Description	Miles of stream	Percent of total
Class 1	Streams with anadromous or adfluvial lake and stream habitat	44.9	23.1
Class 2	Streams with resident fish populations; generally steep (6-15% gradient); can include streams from 0-5% gradient without anadromous fish	17.7	9.1
Class 3	Streams with no fish populations that have potential water quality influence on downstream aquatic habitats	40.4	20.8
Unclassified	Stream that have otherwise not been classified	72.4	37.3
Artifical/complex	Stream that are complex or have artificial pathways	18.6	9.7

Terrestrial Species and Habitats

Terrestrial habitats include a mosaic of wetland and upland habitats. Diverse vegetation types and structures provide diverse habitats for nearly 200 species commonly found on the Kenai Peninsula. The most current data on existing vegetation structure is available from recent mapping work by the Kenai Peninsula Borough (KPB-2007), using Ikonus imagery (Figure 13). The KPB cover classes are described in appendix A.

Vegetation and Structure

The Kenai Peninsula Borough classified the vegetation on 50,704 acres, or approximately 46 percent of the watershed area (summarized in Table 5 and Figure 13, see legend in Appendix A). The unclassified area occurs on the Park Service lands and is primarily snow and ice.

About (33 percent) of the classified area is non-forested (Table 5). Approximately 11 percent is snow and ice, and another 20 percent non-forested alpine tundra (12,269 acres) or grassy meadows (83 acres) which provide summer range and some winter range for mountain goats, Dall sheep (*Ovis dalli*), caribou, and other species. Sub-alpine alders (10,034 acres) provide hiding, resting, and foraging cover for a variety of species. Willows (119 acres) in higher elevations and small aspen/birch provide forage for moose and food and cover for many birds. Wetlands occur on the alluvial valley bottoms providing food and cover for a diverse array of large and small mammals including Trumpeter swans, moose, bear, and birds.

Table 5. Resurrection River watershed Vegetation and Structure

FS Lands in Resurrection River Watershed	Acres	Percent of Watershed
No Structure	23,053	20
Barren/Snow Ice	12,631	11
White Spruce - Large	5,975	5
Mountain Hemlock - Pole	3,180	3
Mountain Hemlock - Large	2,497	2
Sitka Spruce - Large	1,010	1
Aspen - Seed/Sap	952	1
Aspen - Large	461	<1
Aspen/Birch - Pole	410	<1
Aspen/Birch - Large	328	<1
White Spruce - Pole	203	<1
Water	3	<1
Grand Total	50,704 acres,	46%

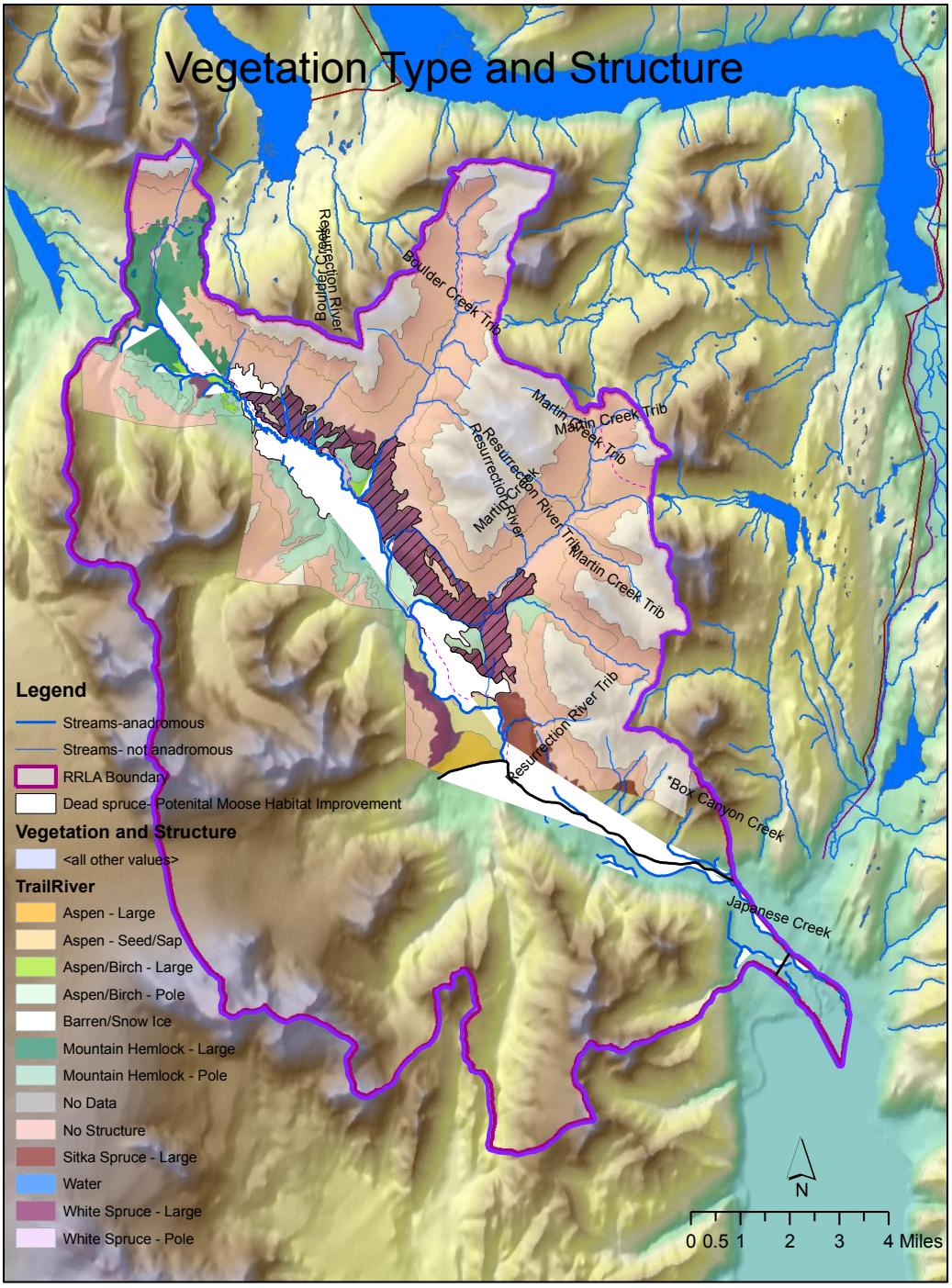

Figure 13. Vegetation and Structure in the Resurrection River Watershed

Table 6. Non-Forested Acres

Vegetation	Acres	Percent of Watershed on FS lands
Alpine	12,269	53
Alder	10,034	44
Willow	119	1
Grasses and Herbaceous	83	<1
Non -forested lowlands	548	2
Grand Total	23,053	100

Forested areas are generally below 1,500 feet, and are primarily pole size mountain hemlock, large Lutz spruce, aspen, and birch communities in a mixture of size classes (See Table 5, and appendix A). Old growth or mature forests provide potential nesting habitat for goshawks, neotropical migratory birds and raptors. They also provide thermal and hiding cover and denning areas for large mammals, travel corridors for moose, bear, wolverine, and wolves, and winter foraging areas for mountain goats. Some larger diameter and/or old growth mountain hemlock and Lutz spruce trees may be present on bench areas, lower slopes, and below ridge tops. Mountain hemlock dominates stands that occur on ridges and convex slopes, providing potential nesting habitat for goshawks, winter foraging habitat for mountain goats, and bedding areas for bear and moose. Canopy gaps with devil's club, steep slope areas with mountain hemlock and blueberry provide forage for bears. Broadleaf forest types, such as mature birch in the stem exclusion phase, support populations of migratory songbirds, such as thrushes and warblers. Succession provides paper birch snags which are good habitat for cavity nesting birds. The KPB classified about 9,482 acres of large conifers (white spruce, Sitka spruce and mountain hemlock). Only 1,750 acres occur in stands that have predominantly live trees, and these are mainly mountain hemlock and Sitka spruce. Most of the large white spruce died from the spruce bark beetle.

Early seral aspen habitats on 952 acres provide feeding habitat for moose, wolves, snowshoe hare, lynx, and nesting habitat for neotropical migrants such as sparrows and warblers.

Pure stands of large aspen are rare and occur on 461 acres. No pure stands of birch were identified. These areas provide habitat for migratory birds and other species.

Other Influences

Salmon runs in Resurrection River and associated tributaries are an important seasonal source of food and support populations of many terrestrial species of wildlife, including brown and black bear, bald eagles, and wolves. Five species of salmon and two species of trout are present. Wetlands provide important nesting and foraging habitat for sensitive species such as trumpeter swans and other waterfowl.

Wildfire, spruce bark beetle infestations, avalanches, flooding, and human activities affect wildlife habitat and influence the structure, distribution, and functions of habitat throughout the watershed (See Current Conditions, Terrestrial Species and Habitats). The spruce bark beetle has affected over 80 percent of large conifer stands. Flooding occurs often on the lower part of the watershed, affecting development and habitat.

The human activities that affect wildlife include float plane activity in route to Upper Russian Lake, small aircraft in route to the western Kenai Peninsula, motorized and non-motorized recreation use in summer and winter on and off existing trails by hikers, snowmachiners, hunters, and flight seers. Development that affects habitat include Forest Service trail systems and infrastructures, private residences and

businesses in or adjacent to Seward, utility and telephone corridors adjacent to the highway and Exit Glacier Road, National Park facilities at Exit Glacier, and the Seward Airport.

Management Areas

Forest Management Areas that emphasize wildlife habitat management include a brown bear core area in the northwest portion of the watershed, which was designed to manage for brown bear population, and to reduce dangerous human/bear encounters.

Fish and Wildlife Conservation Areas emphasize the conservation of specific fish and wildlife habitats. Vegetation should be generally managed for late seral stages although diversity is encouraged. Wildlife viewing opportunities are encouraged. The Fish, Wildlife, and Recreation Management Area is managed to provide a variety of fish and wildlife habitats while also providing recreation, watchable wildlife, hunting and subsistence needs. Vegetation should be managed for diversity of types, age classes, and structures.

Heritage Resources

Prehistoric Period

The prehistory of the Resurrection River watershed is completely unknown, likely due to a lack of cultural surveys in this area. At this time we can only speculate about the prehistoric use by synthesizing regional chronologies from surrounding areas.

Archeological and ethnographic data has documented prehistoric use on the Seward Ranger District in the Early to mid-Holocene (10,000 to 3,000 BP), the Riverine Kachemak (3,000 to 1,000BP) and the Late Prehistoric (1,000 to 200BP) periods. The Late Prehistoric is associated with the Dena'ina culture, who constructed villages containing large multi-family houses and underground cache pits for cold storage (Boraas 2002). The Dena'ina (Kenaitze Indian Tribe) still resides and is active on the Kenai Peninsula today.

Prehistoric use of the Resurrection River drainage is currently not represented by sites with a prehistoric component. However, the Sqilantnu Archaeological District (SEW-00282), which is eligible for the National Register is located just west of the landscape assessment area. The Sqilantnu Archaeological District is associated with prehistoric use of the salmon runs along the Kenai River and Russian River. It is reasonable to believe that further prehistoric sites may exist on the Resurrection River drainage, associated with prehistoric use of the drainage as a route to access salmon runs, and/or a route to access the sea from the Russian River. High-altitude sites associated with seasonal sheep, goat, or caribou hunting may also exist. One high-altitude housepit site has been inventoried just north of the landscape assessment area on Falls Creek. The data suggests that while activity may have been concentrated along streams with salmon runs, and coastal hunting of sea mammals; dispersed activities may also have taken place in high-altitude environments and in areas of high-relief (Dumond 1977; Clark 1982).

Historic Period

The Russians staked their claim on Alaska in the mid eighteenth century, after the voyages of Gvozdev and Bering in 1732 and 1741, respectively (Black 2004:xiii). They occupied parts of the Kenai Peninsula until 1867.

Resurrection Bay was first entered by Siberian fur trader Alexander Baranov in 1792 during a scouting mission to establish a shipbuilding location in Alaska. It was decided that the tall, straight timber on

Montague Island would be perfect building material, and that the inlet on the mainland would be the chosen location for the shipbuilding. Since the inlet had been entered by Baranov on Easter Sunday, it was called Voskresenskaya Gavan, or in English, Resurrection Bay. As the shipbuilding progressed, the Russians needed more iron and they prospected in the Kenai Peninsula Mountains for iron ore. According to historian Mary Barry, “It is said that the burned rocks along the Russian River are remainders from Russian iron smelting attempts. The iron ore was transported down along Resurrection River to the bay” (Barry 1986).

Joseph Cooper, of Kachemak Bay, reported finding gold on Cooper Creek in 1884. This discovery led to a gold rush that focused on the Turnagain Arm area, although evidence of prospecting can be found throughout the Kenai Peninsula.The gold rush period is not represented by any particular sites on the Resurrection River drainage, though activities during this period may have contributed to the features currently inventoried. Much of the mining during the gold rush period consisted of pick and shovel operations, which leave only a very faint archaeological presence.

After the gold rushes subsided, considerable prospecting and mining continued to take place on the eastern Kenai Peninsula.including a few sites within the Resurrection River drainage.. It was at this time, between approximately 1900 and the 1930s that capital-intensive placer mining began in the form of many small, medium, and large hydraulic mining operations. This period also saw the beginnings of lode mining at several locations on the eastern Kenai Peninsula, including Slate and Summit Creeks. In addition, Cooper Landing, a settlement that stretches along the Kenai River, was founded during this period.

Modern Period

During the latter part of the twentieth century, the importance of mining and timber related industries have diminished. Recreation and tourism have come to supplant these industries, and continue into the present. Mining has continued, but most mining is now small operations using low-impact suction dredges, rather than the large operations and impacts of the past.

Recreation

The number one human attraction/destination for this watershed and the entire area is Exit Glacier. Exit Glacier is within Kenai Fjords Nation Park. Recreation use of the Resurrection River Watershed, on National Forest System lands, is primarily concentrated along the Exit Glacier Road (Herman Leirer Road) and the Resurrection River Trail. Recreation use, primarily dispersed camping, occurs on State of Alaska lands south of the Forest Boundary. In early years, use in the watershed, was limited to the lower reaches of Resurrection River near Seward except for a few hardy subsistence hunters and trappers. Construction of the road to “Resurrection Glacier” was started in 1965 by residents of Seward. The devastation of the 1964 earthquake underscored the critical need to diversity Seward’s economy. Seward residents felt that the glacier would be an excellent new sightseeing destination for the expanding road-based tourism economy. By the end of the 1971 construction season, a gravel road that was “generally too rough for many passenger cars” had been largely competed to the east bank of the Resurrection River. A 1.75 mile road was bladed out on the west side of the river in 1970 providing limited access to the Glacier. With the passage of the Alaska National Interest Lands in 1980 Kenai Fjords National Park was created. Shortly after that a pedestrian bridge was constructed at the existing bridge site. A vehicle access bridge was constructed 5 years later. The development of the Resurrection River Trail, which provides access to the upper Resurrection River and connects to the Russian Lakes Trail, was initiated in the 1970’s and completed about 1985. The Resurrection River Public Use Cabin is located along the trail. The cabin can be used by the public on a first come, first served basis. Both the road and the trail offer easier access, increasing the growth and demand for all types of recreation opportunities.

The amount of recreation use within the road corridor of the Resurrection River Watershed on National Forest System land is moderately high because of its ease of access and close proximity to Seward. The majority of the recreation use within the watershed occurs during the summer months (June through August) and coincides with the arrival of seasonal summer tourists. However, the area is an important area for local winter recreation. Use decreases substantially as one moves off of the road and trail system.

The recreation activities taking place in this watershed include hiking, fishing, hunting, trapping, mountain biking, horseback riding, camping, winter Park cabin use, rafting, nature photography, wildlife viewing, dog sledding, berry picking, relaxation with families and friends, cross-country skiing, and snowmachining. Existing recreational facilities on National Forest System lands are the Exit Glacier Overlook, the Resurrection River Trailhead and trail, and the Resurrection River Cabin .

Summer Recreation. The road is open to vehicle traffic from May 1 through Oct 30 each year. Most use within the analysis area occurs during the summer months (approximately June through September). However, the majority of the activities are limited to within a short distance of the Exit Glacier Road. In 1997 more than 300,000 people made a recreational visit to the park, many of which traveled the Exit Glacier Road. In the Alaska Dept of Transportation's Annual Traffic Volume Report 2003 – 2005 the average annual daily traffic count at Box Canyon Creek Bridge is 458 vehicles. Recreation use decreases with increasing distance from the road and trail access routes. In the early 1990s the Exit Glacier Road was reconstructed and paved. During this construction project dikes were constructed off of the road creating additional access to the outwash plain.

These accesses provided places for recreational users to get off of the road and use the open expanse or the plain for walking, camping, , and other activities. The Resurrection River Trail is used primarily for hiking. However it is also traveled utilizing mountain bikes and horses. Most use occurs in the first 6 miles of the trail before it crosses Martin Creek. There is currently no bridge across Martin Creek and it can be difficult to cross during high water flows. Beyond Martin Creek the trail is managed in a more primitive state to the point it joins with the Russian Lakes Trail.

Winter Recreation. Winter season (approximately December through April) supports a wide range of activities because of the easy access to the Seward area. The road is closed from November 1 through April 30 of each year. Winter recreation within the analysis area includes snowmachining, cross country skiing, sled dog mushing and snow shoeing. The type of winter recreation is clearly dependent of the maritime weather influences. Most of the non-motorized use occurs within the first three miles of Box Canyon Creek Bridge, where the road is closed. Ongoing conflicts between motorized and non-motorized winter users do exist on the road. Snow machine use is allowed on State and National Forest System lands. However, little use occurs off of the road. Within the National Park, snowmachine use is only restricted in limited areas around the toe of Exit Glacier and trails in the developed area. There substantial snowmachine use on the outwash plain of the glacier in the winter (See KEFJ Exit Glacier Area Plan). This use is primarily to support the park cabin rental use. There is little use on the trail and lands adjacent to the river during the winter months. However, there is snowmachine use in headwaters of the drainage in upper Resurrection, Boulder and Martin Creeks.

Key Issues and Questions

The following issues and key questions are important for management of the Resurrection River Watershed and provide a framework for the landscape assessment. Some of these questions address natural processes that provide a basis for evaluating other issues. Others are important management considerations and should be evaluated by a variety of resource specialists.

Lands

Issue: Different jurisdictions lead to different management activities, goals, philosophy or objectives.

> **Question:** How does the public know what is permissible on different ownership?
>
> **Question:** Where is the boundary between the National Park, the National Forest, and the State of Alaska?
>
> **Question:** What authorities are out there to may allow management with jurisdictional overlap?
>
> **Question:** Is permitting a problem for outfitter guide activities that lap over multiple jurisdictions.

Geology, Minerals and Soils

What is the potential for mineral development?

Is there a demand for sand & gravel from National Forest System lands?

Is there a demand for rock from National Forest System lands?

Hydrology

Issue: Human uses are limited in the portion of the Resurrection River watershed that lies on National Forest System lands because of limited development. Impacts to streams and rivers from human uses in the watershed include localized impacts related to trails, roads, and development.

> **Question**: How do roads, development, and flood control structures in the Resurrection River watershed affect stream channel processes and water quality?
>
> **Question**: What impacts do recreational uses in the watershed have on stream channel condition?

Issue: Naturally dynamic streams in the watershed and frequent flooding in the area can potentially impact established recreational sites, roads, bridges, and other developments in the watershed.

> **Question**: How do natural channel changes and flooding affect roads, trails, bridges, and developed areas in the Resurrection River watershed?
>
> **Question**: What is the flood history in the Seward area, and how are the flood frequency and flood hazards changing over time?

Issue: Climate change on the Kenai Peninsula is likely to cause gradual changes in precipitation patterns, flood dynamics, and vegetation conditions, potentially affecting stream channel conditions, stream processes, and riparian composition. These potential long term changes are not well understood at this time, but will likely be a factor in resource management in the future.

> **Question**: How are climatic trends affecting glaciers, stream flows, channel morphology, and water quality in the Resurrection River watershed?

Vegetation and Ecology

> **Question:** Based on the proximity to the port in Seward, what is the possibility of introduction of gypsy moth or other non-native insects and plants

Question: How is the current Alder die-back effecting stands and what will replace the alder?

Question : What is the resistance of the stands to insect attacks: how can we maintain an endemic population vs. an epidemic outbreak?

Botany and Weeds

Issue: Non-native Plants

Question: To what extent should control of non-native plants and public education be a management priority?

Issue: Sensitive and Rare Plants

Question: What sensitive and rare plants occur within the watershed and what are their habitat requirements?

Fire and Fuels

Issue: Spruce bark beetle infestation in the watershed may result in an increased risk of natural or human-caused wildfire, with associated degradation of air quality.

Question: Will increased recreation use bring the likelihood of more human caused fires?

Question: Will the spruce bark beetle outbreak in the area, along with increased recreation use, increase the threat of wildfire impacting the drainage area due to unwanted ignitions? **Question:** Will the spruce bark beetle outbreak in the area, along with increased recreation use, increase the threat of wildfire impacting the drainage area due to unwanted ignitions?

Aquatic Species and Habitats

Issue: Little information has been collected in this watershed. All fisheries data comes from the Alaska Department of Fish and Game Anadromous Waters Catalog, with the exception of the Eulachon (*Thaleichthys pacificus*) which were identified in the watershed by Forest Service personnel in 2004.

Issue: Coho salmon (*Oncorhynchus kisutch*) are important to the city of Seward for the annual silver salmon derby.

Question: To what extent does quality spawning and rearing habitat exist for the five species of salmon and other aquatic species within the watershed?

Question: What impacts will current and future land management and development have on water quality; aquatic habitat; and populations of salmon, Dolly Varden, and other aquatic species within the watershed?

Question: What is the occurrence of invasive species such as Atlantic salmon, northern pike, and New Zealand mud snails within the watershed?

Question: What impacts will noxious weeds and other invasive plant and animal species have on riparian areas; streams morphology; populations of salmon, Dolly Varden, macro-invertebrates and other aquatic species within the watershed?

Question: What effect has the road and trail had on stream morphology, fish passage and aquatic organism access to off channel habitat?

Question: What effect has the local gravel company had on the stream morphology, fish passage and aquatic organism access to off channel habitat?

Question: What effect will the infestation of spruce bark beetles and climate change have on frequency of fire, riparian vegetation, habitat complexity and in-stream large woody debris recruitment?

Question: What habitat features are present in the watershed that make it attractive for cohos?

Question: Where does most of the spawning occur – in the main channel, side channels, tributaries?

Question: How does the silty glacial water affect habitat? How do the dynamic channel changes affect habitat?

Terrestrial Species and Habitats

Issue - Development and Human Uses: How are human uses such as recreation sites, trails, roads, aircraft, and motorized and non-motorized use affecting wildlife and habitat? Are wildlife or their habitat needs in conflict with human uses, or human uses impacting wildlife and habitats?

Question: What are effects to brown bears in the core area? Have there been documented bear, human encounters or defense of life or property, and if so, are the trends increasing?

Question: How much snow machine traffic occurs in the alpine areas, and is it influencing movements of goats and wolverines (Thomas Mcdonough, Alaska Department of Fish and Game)?

Question: How will management activities affect access for harvest activities, impact important wildlife habitat such as alpine areas for sheep and goats, and flood plains and salmon streams for moose and bears (ADFG)?

Question: How much development is planned, how much habitat loss will occur, and how will development affect the functioning of wetlands and habitat connectivity?

Issue - Vegetation and the Spruce Bark Beetle: How has the bark beetle affected the mature and old growth conifer availability and fire risk to wildlife habitat?

Issue - Climate Change: How is climate change affecting species and habitats, particularly alpine species?

Question: What are the trends or expected changes for alpine vegetation?

Question: What are the current nutritional condition, health, and population trends of Dall sheep and mountain goats?

Issue - brown bears: Brown bears are of key interest in this watershed because it contains a brown bear core area.

Question: How are human uses (recreation, roads, development) affecting brown bears in the watershed and the core area?

Question: How many brown bears inhabit the watershed?

Question: How are hiking, fishing, flight seeing, and other recreation activities affecting brown bears?

Question: Are there documented bear/ human encounters or DLPs (defense of life or property), and if so, are the trends increasing?

Heritage Resources

Issue: There is a lack of cultural information within the landscape.

Question: Are additional cultural resources present in the watershed which have yet to be documented and where are they located?

Recreation

Issue: There is a need for recreation use data, particularly in the winter across property boundaries.

Question: How can the Forest Service best collect and share recreation use data?

Issue: Management of recreation developments (bike trail/winter non-motorized trail) across jurisdictions.

Question: How can the Forest Service best identify fund, and manage recreation development projects across jurisdictions?

Issue: Management plans and/or regulations that may displace users.

Question: Where do these displaced users go?

Question: When these users are displaced what are the effects on adjacent lands?

Current Conditions

This portion of the landscape assessment discusses the current range, distribution, and condition of resources within the Resurrection River Watershed, and provides a summary of all information relevant to the issues and key questions known about the watershed.

Lands

The land ownership of the analysis area is displayed in Figure 2. The majority of the analysis area is public land managed by the USDA Forest Service and the USDI Park Service. The centerline of the Resurrection River serves as the boundary between these two federal agencies. To date, there are no State or Native corporation selections within the analysis area.

The Resurrection River serves as the property boundary between the USDA National Forest System lands and USDI Park Service lands. As the Resurrection River changes course every year, this boundary is somewhat elastic. In addition, the USDA Forest Service and USDI Park Service have different objectives for land management. The USDA Forest Service is a multiple use agency; whereas, the USDI Park

Service promotes conservation. For this reason, the watershed is subject to different management philosophies that can affect the entire watershed.

There are no public lands orders or conveyances of National Forest System lands in the watershed.

Easements

Alaska Department of Transportation has a 50 foot ROW on the Exit Glacier Road paralleling the river to the Park bridge.

Non-Forest Service Lands

Private property is located adjacent to the State of Alaska owns lands south of sections15, 16, 17, 18 of T1N, R1W.

Geology and Minerals

There are seven management prescriptions within the analysis area and over half of the analysis area is Non-National Forest System lands (see Introduction). The theme and minerals standards and guidelines for each management area are discussed below.

Backcountry Management Area

Locatable minerals activities is allowed consistent with the management intent and mineral material sales are "conditional", the activity is allowed consistent with the management intent, standards and guidelines.

Guidelines

Small mineral materials sites may be developed to support trail or facility development. All sites will be completely rehabilitated upon completion of projects.

Brown Bear Core Area Management Area

Locatable minerals activities are allowed consistent with the management intent, standards and guidelines and mineral material sales are not allowed in the management area.

Guidelines

Mineral exploration activities will include terms and conditions controlling operating methods and times to prevent or control adverse impacts on brown bear habitat and to prevent negative bear-human interactions.

Fish, Wildlife and Recreation Management Area

Locatable and Salable minerals activities are both allowed consistent with the management intent.

Fish and Wildlife Conservation Area Management Area

Both Locatable and Salable minerals are allowed consistent with the management intent and the standards and guidelines.

Guidelines

1. Mineral exploration activities will include terms and conditions controlling operating methods and times to prevent or control adverse impacts to wildlife and fish.

2. Small salable minerals materials sites may be developed to support trail and facility development. All sites will be completely rehabilitated upon completion of the project.

Minerals Management Area

Minerals Management Areas are managed for the exploration, development, extraction, and processing of locatable (base and precious metals, such as gold, silver, and copper, etc.) leasable (oil, gas, coal, hardrock minerals in the Copper River addition, etc.), and salable (sand, gravel, and quarry stone, etc.) minerals.

> This management area prescription was developed to address the "Natural Resource Products--Minerals" Interest and specifies management direction for areas with approved plans of operations.

The Forest Plan LRMP Management Prescription map shows 642 acres (<1 percent) "Mining Claims with Approved Plan (1998)." However, it should be noted that claims are managed by the Bureau of Land Management (BLM) rather than the Forest Service. As a result, approved plans of operations can change and are not necessarily reflected over the life of the land management plan. Currently (April 28, 2010) seven claims are located in the watershed but there are no current plans of operations on these claims.

The LRMP indicates that the "Minerals Management Area" prescription becomes the primary prescription whenever any locatable, salable, or leasable minerals activities but only considered "Mining Claims with Approved Plan (1998)" on the prescription map.

There are no active salable minerals (mineral materials) sources or pits in the analysis area on National Forest System lands however. Metco, a private business, operates a sand & gravel operation on Resurrection River just downstream from the watershed analysis area, above the Seward Highway Bridge, and has a natural replenishing alluvial supply of materials.

Additional needs for mineral materials may be identified and sites established in the analysis area. There is a huge volume of sand and gravel resources with ready road access. The Forest would not go into competition for the available market and would not likely develop a site unless private business could not meet the demand. Quality rock (shot rock, armor stone, etc) is in short supply and high demand can be project driven. If a source is identified with ready road access, development could occur.

Sand and gravel and rock pits are common along all highways and roads on the Kenai Peninsula and were initially developed to support construction of the roads. If adequate mineral materials are identified in any of these pits, additional materials could be extracted if a need is identified.

No leasable minerals activities are foreseeable in the analysis area.

Locatable, Leasable, and Salable minerals activities are allowed consistent with the management intent, standards and guidelines as follows.

Guidelines

Activities, identified in the underlying (initial) management area prescription, are allowed so long as they are compatible with mineral activity and provide for public safety.

Standards

Prior to and following mineral activities, these lands will be managed according to the underlying (initial) management area prescription. With the initiation of mineral activities, apply reasonable regulation of

surface occupancy and use to manage the mineral activities to be as compatible as possible with the underlying (initial) management area prescription. In the case of those mineral exploration and development activities on land interests granted in accordance with the 1982 CNI Settlement Agreement, mineral activities will be managed consistent with the conservation of fish and wildlife and their habitats, as directed in ANILCA, without consideration for the underlying (initial) management are prescription.

Major Transportation / Utility Systems Management Area

Locatable minerals activities and mineral material sales are both allowed consistent with the management intent, standards and guidelines.

Guidelines

Activities, identified in the underlying (initial) management area prescription, are allowed so long as they are compatible with transportation, utility system or electronic site activity and provide for public safety.

Non-National Forest

Over 60 percent of the watershed/assessment area is non-National Forest. The southern and southwestern portions of the Resurrection River watershed analysis area, east of the Resurrection River, are lands managed by the Kenai Fjords National Park and Kenai National Wildlife Refuge. National Parks and National Wildlife Refuges are withdrawn from mineral entry by an Act of Congress so mineral entry has been precluded.

Private, Kenai Peninsula Borough, and State of Alaska lands are at the lower end of the Resurrection River watershed in the southeastern portion of the assessment area. The Forest Service has no regulatory authority to manage these lands. All public domain lands are open to mineral entry under the 1872 Mining Law unless specifically closed.

The National Forest System lands in the analysis area that are open to mineral entry have varying potential for mineral development ranging from "Unidentified" to "Identified Resources, Most Favorable Mineral Potential". The Forest Service must allow reasonable access to mining claims. Metal prices are currently very high (2010) which has increased locatable minerals activities on the Forest. See chapters 2 and 4, mineral potential.

The anticipated need for sand and gravel from the analysis area is low because a private source is in existence in Seward. Sand and gravel needed for future projects could be made available from National Forest System lands for in-service, commercial, and private citizens.

The anticipated need for rock from the analysis area varies based on project requirements. Local sources are limited in the immediate area and rock needed for future projects and should be made available from National Forest System lands if a source is identified.

Soils

Current Conditions

Ecological Hierarchy

A National Hierarchal Framework for soil geomorphology has been developed for the entire Forest Service in an effort to stratify and delineate landscapes (Table 7) based on biotic and environmental factors that directly or indirectly expresses energy, moisture, and nutrient gradients which regulate the functions of the ecosystems (ECOMAP, USDA, Forest Service, 1993). The most general level that

describes the overall shaping processes affecting the landscape on the Kenai Peninsula is the Subsection. This level attempts to place large landscapes with similar geology, lithology, geomorphic process, soil groups, sub-regional climate, and potential natural vegetation into describable units.

Table 7. Hierarchical framework of ecological units

Ecological Units	Ecological Units in the Assessment Area	Purpose, Objectives, and General Use
Domain	Humid Temperate (200)	National planning and modeling
Division	Marine (240)	National planning and modeling
Province	Pacific Coastal Mountains Forest-Meadow (244) Pacific Gulf Coastal Forest-Meadow (245)	National planning and modeling
Section	Chugach Mountain (M244A) St. Elias Mountain (M 244B)	Multi-forest, statewide, & multi-agency analysis
	Northern Gulf Forelands (245A) Northern Gulf Fjord lands (M245A)	
Subsection	Tasnuna River (M244Ac) Turnigan Arm (M244Ae) Western Kenai Mountains (M244Af) Eastern Kenai Mountains (M244Ag) Chugach Icefields (M244Aa) Lowe River (M244Ab) St. Elias Icefields (M244Ad) Copper River Delta (M245Ad) Copper river (M245Ae) Kenai Fjord lands (M245Aa) Prince William Sound Mainland (M245Ab) Prince William Sounds Islands (M245Ac)	Multi & interforest planning and analysis
Landtype Association	Glaciers (00), Mountain Summits (10), Mountain Sideslopes (30), Depositional Slopes (40), Moraines (60), Coastal (70), Outwash (80), Hills (90)	Forest watershed or landscape analysis planning

Subsections

For an ecosystem assessment at this scale, the subsection and landtype association units are the most appropriate. Subsections which comprise in the Resurrection River Assessment Area include:

Western Kenai Mountains Subsection (Map Unit M244Af)

The rounded mountains are the result of frost action and valleys that were initially shaped by glaciers originating in the Eastern Kenai Mountains Subsection. Many of the glacial landscape features of this subsection have been masked by subsequent alluvial and colluvial processes. Precipitation ranges from 20 inches in the valleys to 80 inches in the alpine and a 20 to 60 inch snowpack, respectively. The vegetation

of the alpine and some of the mountain sidelopes is dominated by dwarf scrublands and herbaceous types. The remainder of the sideslopes and the valley bottoms are covered with a mixed needle leaf/broadleaf forest that is highly influenced by past fires.

Eastern Kenai Mountains Subsection (Map Unit M213Bc)

Previously glaciated, relatively jagged mountains and alpine valleys are overlain with glacial till on the sideslopes and glacial outwash in the valleys. The climate in this subsection still produces sufficient amounts of snow to retain alpine glaciers in the upper ends of the valleys. Precipitation ranges from 30 inches in the valleys to 80 inches in the alpine and a 40 to 120 inch snowpack, respectively. The vegetation of the alpine and some of the mountain sidelopes is dominated by dwarf scrublands and herbaceous types. The remainder of the sideslopes and the valley bottoms are needle leaf forest characterized by Lutz spruce and mountain hemlock with a mixed needle leaf/broadleaf forest and black cottonwood in the valley bottoms.

Kenai Fjord lands Subsection (Map Unit M245Aa)

Only a small part of this subsection occurs on the Forest and it includes the lower Resurrection River valley and adjacent glaciated sideslopes, and the area north of Seward up to Kenai Lake. It consists of outwash and rolling hills in the valley bottoms and the adjacent glaciated sideslopes. The annual precipitation at sea level of this subsection is about twice that of the other subsections on the Kenai Peninsula. Precipitation ranges from 100 inches in the valleys to 150 inches in the alpine and a 20 to 80 inch snowpack, respectively. The characteristic vegetation in the alpine and some of the mountain sidelopes is dwarf scrublands and herbaceous types. The remainder of the sideslopes and the valley bottoms are needle leaf forest characterized by Sitka spruce and mountain hemlock.

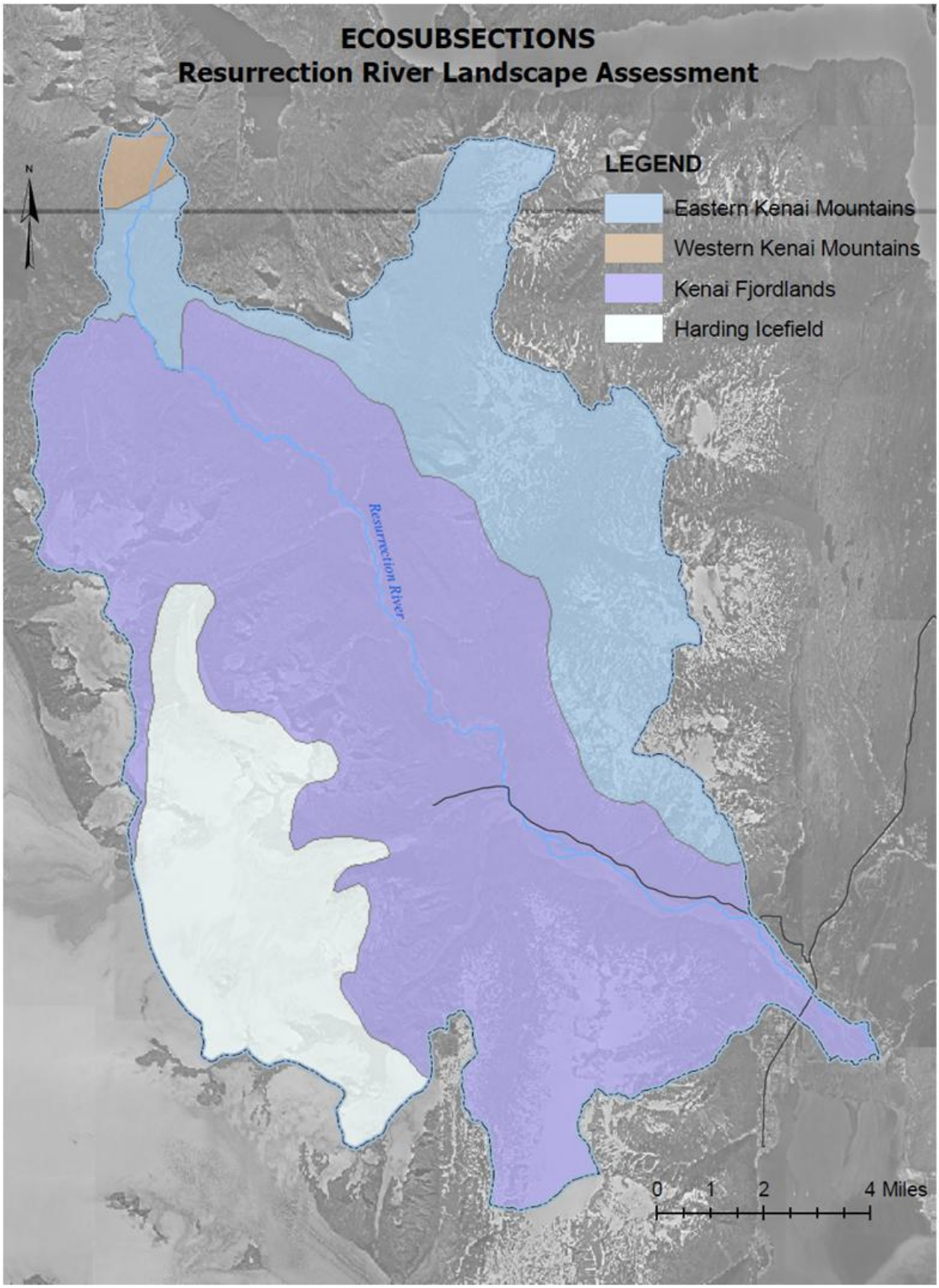

Figure 14. Subsections in the Resurrection River

Table 8. Subsection unit area within the assessment

Subsection	Acres	Unit Code
Eastern Kenai Mountains	25988	M213Bc
Harding Ice field	17396	M245Aa
Kenai Fjord lands	65450	M245Aa
Western Kenai Mountains	983	M213Bb

Landtype Associations

The landtype association level is the next level below the subsection. This is the highest level in the hierarchy that describes landscape (Table 7). At this level ecological units are defined by the geomorphic process and how it affects the topography, surficial geology, local climate, soils, and potential natural vegetation patterns. This is the level that is use for forest level planning because it is broad enough to identify and compare landscape characteristics and general limitations for management activities.

The landtype associations are divided into eight categories. A brief description is given for each landtype association below

Mountain Summits

This association includes the ridges, peaks, cirque headwalls and basins, and associated talus and scree slopes. Glaciation has been the most dominant historic geomorphic force which shaped the landscape. Frost churning has resulted in some cases rounded mountain tops and ridges cover by a layer of loose rock patterned ground. The vegetation is mostly low growing forbs, grasses, and lichens where there is sufficient soil, with some dwarf willows and other woody plants in localized areas. Avalanches and rock fall are very common on these landscapes.

Glaciers

This association includes all active glaciers and ice fields and they include rock peaks or nunataks. The major process is the formation and movement of ice and all associated rock and soil.

Mountain Sideslopes

This category includes all sideslopes, glaciated or unglaciated, smooth or irregular, that normally receive surface or subsurface water draining from alpine landscapes. Slope steepness normally ranges from 15 to 70 percent. The most dominant process shaping the steeper slopes in this category is erosion and transport downslope due to gravity. Erosion from surface water usually results in a parallel drainage pattern with V-notched channels of variable depths and densities. Other soil and rock that is loosened by frost and water rolls down the slopes or is carried down by avalanches. This material is deposited on the lower, less steep slopes. The soils are normally medium textured, well drained, and moderately to well developed. Some of these soils on the lower slopes consist of compact glacial till which are more poorly drained and less productive for forests than other soils in the association. The upper sideslopes are commonly vegetated with low growing subalpine plants which grade into mixed communities of grasses, shrubs, and trees on the lower slopes. The location of trees is strongly dependent on disturbance by avalanches. Steep slopes, V-notches, avalanches, and the potential for erosion are the major limitations to management in this association. Wet soils will be more common at the base of longer slopes. Exposure of mineral soils must be kept to small areas on all slopes to prevent erosion and retain soil productivity. Extra care needs to be taken to retain the organic layer where soils are shallow on the hill slopes.

Depositional Slopes

This association includes the lower depositional foot slopes at the bottom of the Mountain Sideslopes and river terraces that have high cutbanks and are no longer affected by floods or active river cutting. These landscapes normally receive water from runoff from adjacent uplands and are the depository for eroded sediment. The drainage pattern is usually dendritic. The soils are usually well drained, deep, and medium to coarse textured except immediately below long sideslopes where the drainage may be poor due to the accumulation of subsurface runoff. Some of these soils consist of compact glacial till which are more poorly drained and less productive for forests than other soils in the association. Slope gradient is usually less than 35 percent. Vegetation can range from lush grasses and herbaceous plants to old growth forests. The vegetation is strongly dependent on disturbance by avalanches. The major limitations to management in these units will be the poorly drained and wet soils normally found at the base of long sideslopes, numerous small water channels, and avalanches.

Moraines

This association includes all major glacial depositional features such as glacial moraines, esters, kettles, and kames. Occurrences are normally at the junction of two glaciers, adjacent lower mountain sideslopes, or in the bottoms of glacial valleys. Most of the relief is in mounds ranging in height from 10 to 100 feet with slope gradients of 25 to 65 percent. The soils are poorly to well drained and consist of poorly-sorted gravel, cobbles, and stones, in a moderate to fine textured matrix. Drainage depends on slope as well as permeability of the soils. Trees are normally found on the sideslopes and tops of moraines. Wetter vegetation is commonly found in the lower basins in between the moraines. Large boulders in the moraines can frequently cause difficulty for excavation. Wet areas or wetlands in the lower areas will often require special consideration.

Coastal

This association includes landscapes which are the result of marine processes such as tidal fluctuations, wave carving and splash, and blowing sand. Examples include estuaries, beaches, marine deltas, and marine terraces. Most often these sites have slopes less than 15 percent. The soil may consist of either poorly drained silts deposited in low energy environments or well drained sands deposited in high energy environments. Some of the landscapes have been uplifted by isostatic rebound after glacial recession or from earthquakes. Uplifted landscapes are no longer associated with the active processes of the ocean and may be located inland from the ocean. The vegetation found on these landforms depends on how long the site has been separated from active wave processes and the drainage of the soil. Old uplifted beaches are some of the most productive forested sites on the forest. The poorly drained soils on deltas or tidal flats, and marine terraces produce the largest expanses of wetlands. Most of the higher energy sandy soils have thin organic layers on the surface which must be retained for reforestation. Removal of large areas of the surface organic layer will significantly reduced the reforestation potential and allow for soil erosion. The poorly drained silty soils that occur on level areas normally support wetlands should be treated as such. If these soils occur on sideslopes they will be very susceptible to landslides, especially where cut slopes are made for roads.

Outwash

This association includes all landscapes that are a result of fluvial deposition of sediment as a result of upland erosion, including glacial erosion. Much of this association is exposed to occasional or frequent flooding depending on the proximity to rivers. Examples are alluvial plains, glacial outwash plains, braided glacial rivers and the included islands or sand bars, low relief river terraces, and narrow valley bottoms that contain a combination of the above landscapes. This association also includes large sand dunes. The soils include both poorly drained lacustrine silts and clays, and well drained alluvial loams,

sands, and gravels. The vegetation on the poorly drained, fine textured soils will be indicative of wetlands where the surface is level, and poorly productive forests on gentle slopes. The coarse textured soils will produce highly productive forests. All the fine textured soils that occur on historic cut slopes produce landslides naturally or from incompatible management activities. The finer textured soils commonly support wetlands on level surfaces. The relatively thin organic surface layer in coarser textured soils must be retained or mixed with the mineral soils for reforestation.

Hills

This association includes hills and plateaus that do not receive surface or subsurface water flow from uplands. This excludes major rivers or creeks that may flow through the hills that originate from other areas. The surface character of these landscapes is often controlled by the stratigraphy of the bedrock. These landscapes are frequently covered by a veneer of glacial till. The soils are normally well drained, medium to coarse texture on the sidelslopes, and poorly drained fine to medium textured and shallow in the basins or low areas between the hills. The vegetation will usually consist of forested communities on the slopes and hilltops where the soils are well drained. The vegetation in the small basins or inter-fluves will commonly be associated with wet soils. All the sites located in the basins or low areas will likely have either wet soils or wetlands and should be managed as such. Exposure of mineral soils must be kept to small areas on all slopes to prevent erosion and retain soil productivity. Extra care needs to be taken to retain the organic layer where soils are shallow on the hill slopes.

Landtypes

Landtypes are the next level below subsections and landtype associations in the geomorphic classification hierarchy and are commonly delineated at scales of 1:24000 to 1:63360. Geomorphic process, landform, and surficial geology are usually the first criteria used to separate a landscape into landtype units. Following the convention of the classification hierarchy overlapping one level above and below the selected level (landtype association and landtype phase), landtypes are influenced by climate, lithology, and structure, soil weathering phase and vegetation, respectively. Landtypes are identifiable by visible surface features, so one can identify the kind of map unit delineation and similar delineations from either the ground or on appropriate-scale remote sensing resources once their identifying characteristics are known. Along with the differentiating criteria, accessory characteristics are important and useful features of landtypes. The two most common and important accessory characteristics in a landtype layer are soil and vegetation. Soil is usually classified at the family level of soil taxonomy in landtypes. Landtypes contain a predictable soil pattern, with a defined percentage of the area within a landtype. For the Resurrection River Assessment, the source for landtype soil accessory data is Soil Resource Inventory of the Kenai Peninsula (Davis et al. 1980), and several unpublished data sets from the Chugach NF. Likewise, vegetation patterns must exhibit a predictable pattern and a defined percentage of an area within a landtype. Commonly, landtypes use habitat types as their vegetative characteristic. Where habitat types have not been defined, as is the case in the Resurrection River watershed, either a surrogate climax plant community such as dominance type is used, or a local system which relates local classifications to meet the criteria and purposes of the landtype hierarchy is used. For Resurrection River watershed, the source for landtype vegetation accessory data is Plant Community Types of the Chugach National Forest, south central Alaska (DeVelice et al. 1999).

Specific to Resurrection River, Figure 15 shows the land types that occur in the watershed. Soil data are very limited in the assessment area, but there is coverage of some of the major valley bottoms and adjacent lower slopes (see Figure 16). The map unit legend for the soils coverage includes the map number. The map unit identification is presented in Table 9.

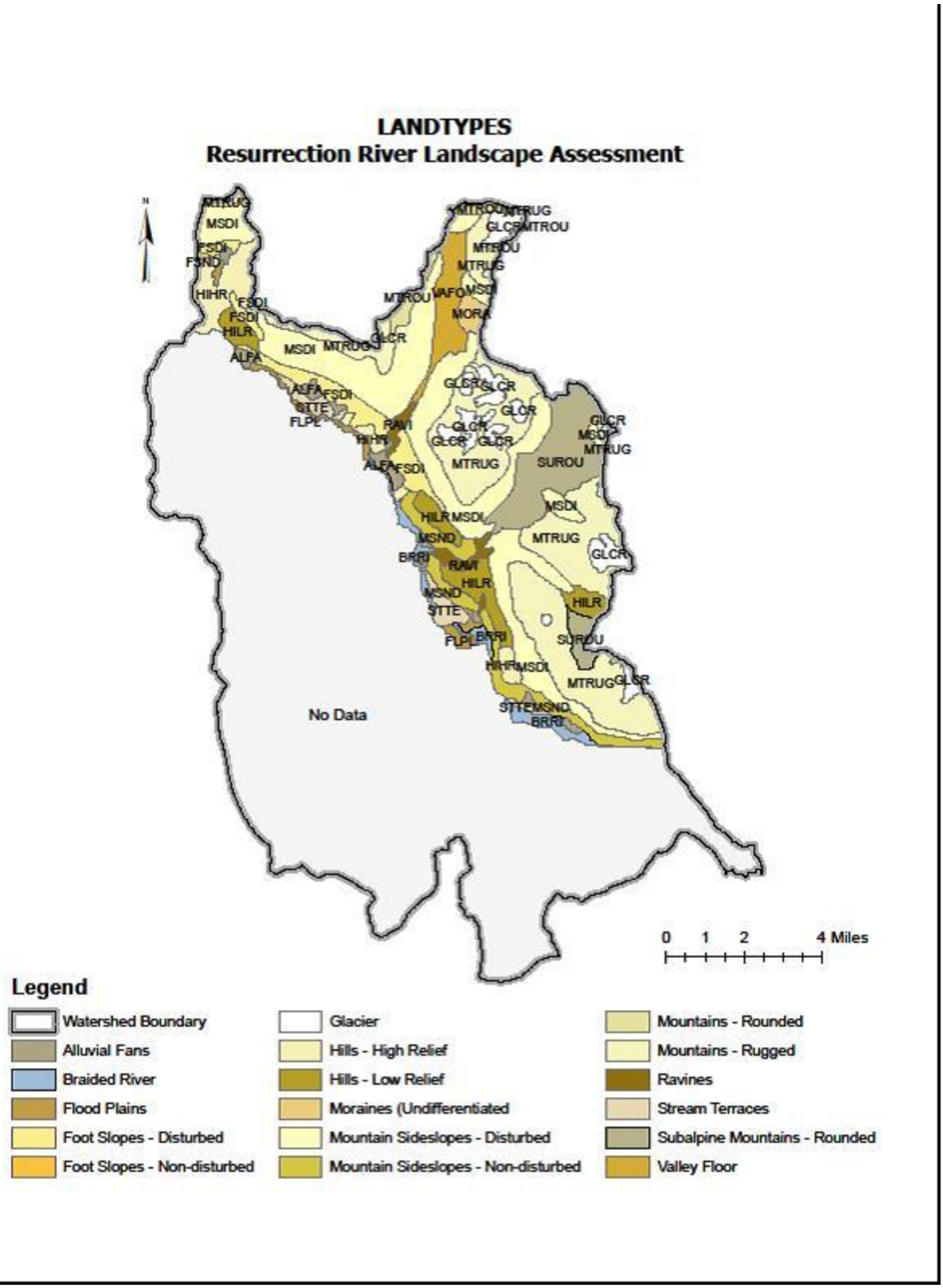

Figure 15. Landtypes in the Resurrection River Landscape Assessment Area

GLCR - Glacier (13)
Large glaciers and ice fields and the included rocky mountain peaks and ridges. Continuous glaciers and rock peaks with little or no vegetation.

MTRUG - Mountains - Rugged (11)
Includes the jagged rocky ridges, peaks, associated sideslopes, cirque basins, headwalls, and rock glaciers that are the result of past or present alpine glaciation or cryoplanation. Field attributes:

1. Usually jagged, rocky summits and ridges
2. Internal relief is usually greater than 100 feet
3. Dominant slope gradient is greater than 65 percent
4. Exposed bedrock and talus comprise greater than 50 percent
5. May have numerous shallowly incised stream channels

MTROU - Mountains - Rounded (12)
Rounded ridges and summits and the associated shoulder slopes which have not been glaciated, but are more the result of present General Picture cryoplanation.

Field attributes:

1. Rounded non-glaciated mountain summits and ridges
2. Does not include glaciers larger than 40 acres
3. Internal relief is generally less than 100 feet
4. Slope gradient is usually less than 65 percent
5. Slopes are usually convex
6. Incised stream channels are rare; most run off is subsurface

SUROU - Subalpine Mountains - Rounded (14)
Those mostly rounded ridges, hill tops, and plateaus that have shrub, graminoid, and herbaceous vegetation that is very characteristic of subalpine conditions.

Field attributes:
1. Mid elevation broad ridges, ridge summits, and hill tops
2. Does not include perennial snow fields or glaciers
3. Internal relief is less than 100 feet.
4. Overall slope gradient is less than 45 percent.

MSND - Mountain Sideslopes - Non-disturbed (31,32,35)
Long sideslopes of high relief that normally occur below alpine landscapes that are not disturbed on a frequent basis by rock fall, slides, and avalanches. These slopes are normally forested where they have been exposed by glacial recession for sufficient time periods. Younger slopes may still be covered by shrubs, grasses, and herbaceous plants.

Field attributes:
1. External relief is usually greater than 1,000 feet.
2. Greater than 40 percent of the map unit has trees that area periodically separated by active avalanche and scree slopes.
3. The drainage pattern is usually parallel with infrequent shallowly incised channels.
4. The incised drainage channels make up less than 40 percent of the map unit.

MSDI - Mountain Sideslopes - Disturbed (31, 32, 35)
Long sideslopes of high relief that normally occur below alpine landscapes that are not disturbed on a frequent basis by rock fall, slides, and avalanches. These slopes are normally covered with shrub, graminoid, and herbaceous plants as a result of relatively frequent avalanches, rock falls, soil creep, etc.

Field attributes:
1. External relief is usually greater than 1,000 feet.
2. Less than 40 percent of the map unit has trees that area periodically separated by active avalanche and scree slopes.
3. The drainage pattern is usually parallel, with infrequent shallowly incised channels.
4. The incised drainage channels make up less than 40 percent of the map unit.

MSBR - Mountain Sideslopes - Broken (36)
Long sideslopes of high relief that normally occur below alpine landscapes, where the parallel drainage pattern is broken by benches or knobs. These slopes may or may not be disturbed by avalanches, rock falls, etc. in some areas.

Field attributes:
1. Contains many benches and knobs with a relief greater than 50 feet that break up the continuity and drainage characteristics of the sideslopes.
2. External relief is usually greater than 500 feet.
3. Slopes usually have greater than 65 percent gradient except on benches or knobs where the gradient is usually less than 35 percent.
4. Irregularities usually make up more than 40 percent of the map unit

MSFD - Mountain Sideslopes - Dissected (38, Original Chugach 111,112,113,114 Landtypes)
Long sideslopes of high relief that normally occur below alpine landscapes or large rock cliffs that are commonly disturbed on a frequent basis by rock fall, slides, and avalanches confined mostly to deeply incised, parallel, drainage channels. The deeply incised channels are the sites of intensive weathering on highly fractured or soft bedrock and the subsequent channelization of water and erosion of soil.

Field attributes:
1. Slope gradient is usually greater than 65 percent.
2. Slope length is usually greater than 1000 feet.
3. An intensive dendritic or parallel drainage pattern.
4. Commonly found on a marine sedimentary mudstone or siltstone bedrock.
5. Dissections or drainage channels make up greater than 40 percent of the map unit.

FSND - Foot Slopes - Non-disturbed (33, 51)
The mostly tree covered lower, concave portion of glaciated side slopes that is the result of glacial carving and the deposition of coluvium from the above sideslopes.

Field attributes:
1. Located in footslope positions
2. Average slope gradient is less than 35 percent

3. Greater than 40 percent of the map unit is vegetated by trees.
4. Map unit usually consists of deep alluvial and colluvial material eroded from glacial till on the above slopes.

FSDI - Foot Slopes - Disturbed (34, 51)
The mostly shrub, graminoid, or herbaceous covered lower, concave portions of lower glaciated sideslopes ;that are the result of glacial carving and the deposition of coluvium and avalanche debris from the above sideslopes. Elevation and climate commonly influence the plant species.

Field attributes:
1. Located in footslope positions
2. Average slope gradient is less than 35 percent
3. Less than 40 percent of the map unit is vegetated by trees.
4. Map unit usually consists of deep alluvial and colluvial material eroded from glacial till on the above slopes.

KAMO - Kame Moraines (63)
A mosaic of small hills, basins, and ablation deposits of glacial moraine origin that may be covered by any deposition of glacial moraine origin that may be covered by and vegetation depending on elevation and time since deposition.

Field Attributes:
1. Topography is undulating, being composed of numerous knobs and water filled depressions
2. Slope gradient usually ranges from 5 to 35 percent
3. Relief usually is less than 100 feet between knobs and depressions
4. Located on till plains and outwash plains

MORA - Moraines (Undifferentiated) (65, Old Map Unit 71 on the Chugach))
Terminal, lateral, and medial moraines left by glacial recession. Commonly vegetated by any plant species depending on the elevation and time since deposition.

Field attributes:
1. Terminal, lateral, and thick ablation moraines
2. External relief is usually less than 200 feet.
3. Slope gradient ranges from 35 to 65 percent.
4. Usually restricted to lowlands and the lower portion of the valleys.

ESTU - Estuaries (71)
Mostly level marine landscapes, either nonvegetated or covered by emergent plant species that consist of fine grain marine sediments which are normally inundated daily by ocean tides.

Field Attributes:
1. Contains the mouth of streams as they enter the sea water.
2. Inundated by saltwater during tidal fluctuations.
3. Contains relief of less than 15 feet.
4. Slope is less than 5 percent.
5. Exposed at mean low tide.

BEAC - Beach(72)
Beaches associated with active wave wash and those immediately landward that are not vegetated or thinly vegetated. Also includes small sand dunes commonly integrated with the sandy beaches.

Field attributes:
1. Sandy and gravely beaches along the coasts.
2. Influenced by tidal fluctuations and wave splash and windblown sands.
3. These areas are not normally completely stabilized by vegetation.
4. Relief is less than 25 feet.
5. Slopes range from 5 to 35 percent.

SESL - Sea Slopes (73)
Very steep slopes that are actively raveling soil and rock because of continuous or recent salt water wave action at the base of the slope. Field attributes:

1. Dominated by unvegetated soils and exposed bedrock on wave cut slopes adjacent to salt water.
2. External relief usually ranges from 50 to 200 feet.
3. Slope gradient is usually greater than 65 percent.
4. Complete map unit may include flat upper benches which break abruptly down a very steep scarp.

RABE - Raised Beaches (74)
Historic beaches vegetated by trees and shrubs that were uplifted tectonically and are no longer exposed to active wave wash.

Field attributes:
1. Beaches are no longer exposed to wave splash
2. Consists or curvilinear mounds
3. External relief is usually less than 50 feet
4. Slope gradient is less than 35 percent

RATF - Raised Tidal Flat (76)
Marine deltas, covered by graminoid, herbaceous, and shrub vegetation, that have been tectonically uplifted and is no longer exposed to tidal activity.

Field attributes:
1. This map unit is restricted to large marine deltas that are normally characterized by incised slough channels and shallower ponds.
2. Slope gradient ranges from 0 to 5 percent
3. Internal relief is usually less than 10 feet
4. External relief is less than 15 feet.

MATE - Marine Terraces (77)
Includes those levels, tectonically uplifted, non-vegetated areas of bedrock that are inundated by salt water and are adjacent to islands.
Field attributes:

1. Relatively level landscape of jagged bedrock recently lifted above the effects of the surf.
2. External relief is usually less than 25 feet.
3. Slope gradient for the map unit as a continuous unit is less than 5 percent.
4. Map unit is adjacent to the ocean.
5. Usually contains bedrock buttresses or scarps adjacent the ocean with deeply incised stream channels.

ALFA - Alluvial Fans (81,52)
The fan shaped, tree or shrub covered, alluvial landform that normally forms where the slope gradient decreases at the mouth of creeks.

Field attributes:
1. Composed of deep surfical alluvial deposits located at the mouth of a side valley or tributary stream channel.
2. Average slope gradient is usually less than 25 percent.
3. External relief is usually less than 100 vertical feet.
4. Stream channels are usually somewhat unstable.

FLPL - Flood Plains (82, 53)
Low, flat, tree, shrub, graminoid, or herbaceous covered plains that are subjected to periodic spring and early summer flooding from adjacent clear water creeks.

Field attributes:
1. Develop in and below clear water nonglacial streams NOT associated with active glaciers.
2. Flooding is usually the result of spring snow melt runoff or large rain storms
3. Usually has a slope gradient less than 5 percent.
4. Stream pattern is usually meandering or braided.
5. Dominated by deep alluvial deposits

BRRI - Braided Rivers (83, 53)
Large glacial river channels and the included mostly non-vegetated sand and gravel bars.

Field attributes:
1. Restricted to valley bottom and lowland areas.
2. Usually has a slope gradient less than 5 percent.
3. Surfaces usually have very little vegetation.
4. External relief is less than 20 feet.
5. Contains active streams and unstable sand and gravel bars.

OUPL - Outwash Plains (84)
Low, flat, tree, shrub, graminoid, or herbaceous covered plains that are subjected to periodic mid and late summer flooding from nearby glacial rivers.

1. Develops below and is the result of glacial runoff
2. Flooding is usually dominated by high melt-water runoff from glaciers and rain storms
3. Usually has a slope gradient less than 5 percent
4. Rivers are aggrading and usually have a meandering or braided pattern
5. Dominated by deep alluvial deposits

RAVI - Ravines (85, 84, 37)
Steep sided deeply incised cuts where water erosion has cut into the underlying bedrock or alluvium.

Field attributes:
1. Restricted to Mountain or hill slopes.
2. Slope gradient is usually greater than 65 percent.
3. External and internal relief is usually between 50 and 200 feet.
4. Sideslopes are usually dominated by V-notches of varying depths.

VAFL - Valley Floor (86)
Depositional deposits normally found in small or narrow valleys where individual landforms cannot be delineated because of mapping scale.

Field attributes:
1. Normally found in narrow to moderately wide valley bottoms and have a typically small and very narrow flood plain
2. Landforms are the result of alluvial processes
3. Most slope gradients range from 0 to 35 percent
4. Internal and external relief is usually less than 50 vertical feet and normally between 10 and 35 feet.

DUNE - Dunes (87, 78)
Vegetated or non-vegetated hills of sand. Most sand dunes are located at the mouth of the Copper River and other large river canyons.

Field attributes:
1. Longitudinal sand dunes usually located at the mouth of very large canyons
2. External relief ranges from 10 to 75 feet
3. Length normally ranges from 50 to 5,000 feet.

STTE - Stream Terraces (89)
Mostly tree and shrub covered river terraces that are normally found in valleys where rivers have eroded incised channels in previously deposited alluvium. These terraces have sufficient relief so they are not affected by flooding or annual fluctuations of the water table.

Field attributes:
1. Restricted to valley bottoms
2. Consists of deep alluvial deposits that are no longer exposed to floods.
3. Flat or gently undulating surface where the slope gradient is usually less than 5 percent.
4. Usually adjacent to a steep cut slope (gradient greater than 65 percent) where the original drainage channel has cut down through much of the deposits.
5. External relief is usually greater than 15 feet.

FLLO - Flat Lowlands (62, Old Map Unit 105 in EPWS on the Chugach)

Smooth and flat usually graminoid, herbaceous, or shrub covered topography found on valley floors or coastal plains vegetated by wetland plant species.

Field attributes:
1. Dominant slope is less than 5 percent.
2. External and internal relief are less than 5 feet.
3. Stable landforms may contain ponds, but they are not normally associated with flooding.
4. Rarely are there stream dissections such as are common in map units 101 and 102.
5. Normally consists of bedrock overlaid by marine or alluvial deposits.

HIGS - Hills - Gentle Slopes (61)
Mostly graminoid, herbaceous, and shrub covered undulating topography where bedrock or unconsolidated soil is overlain by accumulations of peat.

Field attributes:
1. Dominant slope gradient ranges between 5 and 35 percent.
2. Relief is less than 50 feet between hill tops and depressions.
3. In undulating topography the hills and knobs make up the minor component.
4. Depressions are not normally fill with ponds or water.
5. The plant communities are normally dominated by wetland plant species.

HILR - Hills - Low Relief (91, 101, 42)
Bedrock controlled undulating hills of low relief that are characterized by shallow soils over bedrock with ponds or wetlands in low basins in between the hills.

Field attributes:
1. Slope gradient is usually greater than 35 percent
2. External relief ranges from 50 to 200 feet.
3. Usually occur from 0 to 1500 feet in elevation.
4. Landscape may be dissected by gorges 50 to 200 feet deep cut into bedrock.
5. This landtype will commonly have a less forested area than the Hills - High Relief Landtype.

HIHR - Hills - High Relief (92, 102, 43, 44, 46)
Bedrock controlled knobs and hills of moderate relief that are characterized longer and steeper slopes and fewer ponds than in the Hills -Low Relief Landtype. Field attributes:

1. Slope gradient is usually greater than 35 percent.
2. External relief ranges from 200 to 1000 feet.
3. This landtype will commonly have more forested area than the Hills - Low Relief Landtype.
4. Usually occur from 0 to 1500 feet in elevation.
5. Landscape is commonly dissected by gorges 50 to 200 feet deep cut into the bedrock.

The soils data and mapping available for the Resurrection watershed cover only the major valley bottoms/adjacent slopes and road corridor in the quartz creek watershed. This survey does not meet Terrestrial Ecological Unit Inventory (TEUI) standards for soils (2005), or National Cooperative Soil Survey (NCSS) standards for inventory. The rest of the area has no soil data at either the plot or polygon level.

Area of each unit (subsection, landtype, and soil management unit) in acres is presented in Table 8, **Error! Reference source not found.**, and **Error! Reference source not found.**, respectively.

Landtype Phase (Soil Management Units)

The landtype phase in the geomorphic hierarchy (soil management units on the Chugach N.F.), is a refinement at both scale and unit differentia, usually delineated at between 4 inches per mile and 2.64 inches per mile (representative fraction between 1:15,840 and 1:24,000 respectively). It is both the Forest's most detailed land systems inventory and soil taxonomic unit. Both soil spatial and attribute (tabular) data are relatively scarce across the Forest, and are particularly scarce in this watershed. Figure 16 shows the identification and distribution of soil management units within the analysis area. See Table 9 for the composition and classification of the soil units.

Table 9. Soil taxonomic classification by soil management unit

Map Unit Symbol	Dominant Soil Subgroup(s), family, mineralology class, and slope class (%)
101D	Typic Cryorthods, medial-skeletal, mixed; 26-45%
102D	Lithic Cryorthods, loamy-skeletal, mixed; Typic Cryorthords, loamy-skeletal, mixed; 26-45%
102E	Lithic Cryorthods, loamy-skeletal, mixed; Typic Cryorthords, loamy-skeletal, mixed; 46-65%
102F	Lithic Cryorthods, loamy-skeletal, mixed; Typic Cryorthords, loamy-skeletal, mixed; 66-100%
202A	Dystric Cryochrepts, loamy-skeletal, mixed; 0-8%
202B	Dystric Cryochrepts, loamy-skeletal, mixed; 9-15%
202C	Dystric Cryochrepts, loamy-skeletal, mixed; 16-25%
205E	Dystric Cryochrepts, loamy-skeletal, mixed; Typic Cryorthods, loamy-skeletal, mixed; 46-65%
304A	Typic Cryofluvents, coarse-loamy, loamy-skeletal, mixed; 0-8%

Table 10. Acres by landtypes in the Resurrection River Assessment Area

LANDTYPE_CODE	Acres
ALFA	806
BRRI	1018
FLPL	646
FSDI	2025
FSND	26
GLCR	2342
HIHR	2026
HILR	2121
MORA	368
MSDI	11309
MSND	2008
MTROU	661
MTRUG	11275
RAVI	614
STTE	898
SUROU	3810
VAFO	1485

Table 11. Acres by soil management units

SMU	Acres
101D	7
102D	19
102E	469
102F	159
202A	38
202B	16
202C	4
205E	42
304A	271

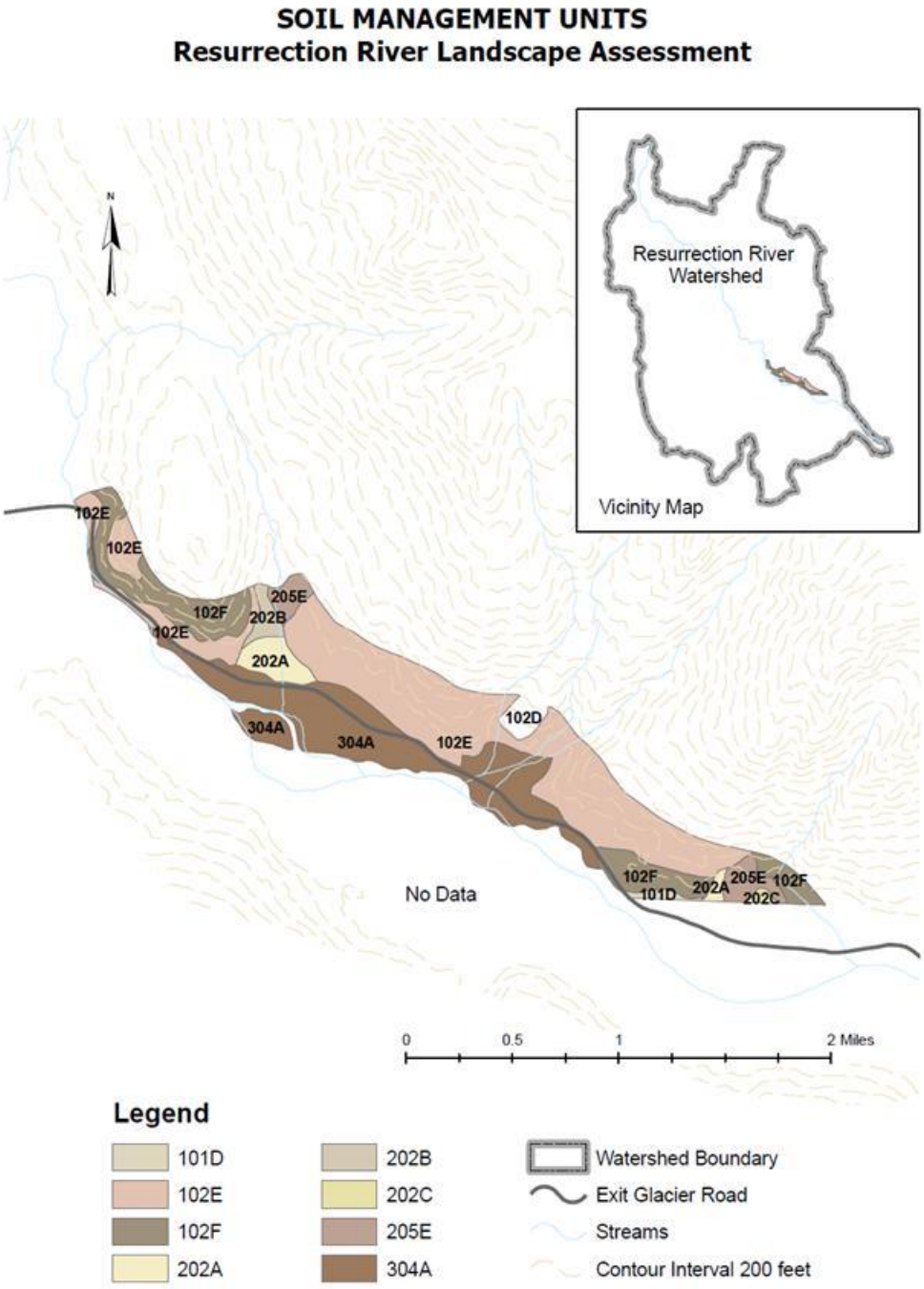

Figure 16. Soil management units

Wetlands

Wetlands categorized and identified by the National Wetlands Inventory of the US Fish and Wildlife Service (Cowardin 1979) that are located on the Kenai Peninsula and identified in the assessment area include:

Estuarine

Includes both estuaries and lagoons, where wetlands that are usually semi-enclosed by land but have at least sporadic access to the open ocean, and that ocean is at least partially diluted by fresh water runoff from the land. Includes marine and deep water marine. While there are shrub/forest wetlands are also estuarine, in the Resurrection River assessment area they are all classified as palustrine.

Riverine

Includes all wetlands where water is usually flowing.

Lacustrine

Includes permanently flooded lakes, reservoirs, and tidal lakes with ocean-derived salinity below 0.5 percent. Includes freshwater pond and lake.

Palustrine

Either not influenced by ocean tides or if influenced by ocean tides, salinity less than 0.05 percent. Persistent emergents, trees, shrubs or mosses cover 30 percent or more of the area. Includes freshwater emergent and freshwater shrub and forest. While there are shrub/forest wetlands that are estuarine, in the Resurrection River assessment area they are all classified as palustrine.

These wetlands are distributed among the landtype associations as showing in Table 12. Landtype associations; Mountain Sideslopes (30), Depositional Slopes and High Relief Terraces (40), Fluvial Valley Bottoms (80), and Hills and Plateaus (90) contain most of the tree dominated community types. The wetlands contained in these associations would be the most likely to be affected by soil disturbing land management actions.

The data in Table 12 indicates that the greatest occurrence of wetlands in the Fluvial Valley Bottoms (80) Landtype Association, with decreasing amounts of wetlands in the Hills and Plateaus (90), Depositional Slopes and High Relief Terraces (40), and the Mountain Sideslopes (30). These four associations, as indicated above, account for the majority of the forested community types, and are most likely to be affected during any timber fuels management activities.

Table 12. Wetlands by landtype association

WETLAND TYPE	LANDTYPE ASSOC	LANDTYPE CODE	Acres
Estuarine and Marine Deepwater			8.4
Estuarine and Marine			123.1
Freshwater Emergent	10	MTROU	2.3
	30	MSDI	4.8
	40	ALFA	1.5
	40	FSDI	0.6
	40	MORA	8.3
	40	STTE	11
	40	SUROU	2
	40	VAFO	11.1

WETLAND TYPE	LANDTYPE ASSOC	LANDTYPE CODE	Acres
	80	FLPL	39.4
	90	HIHR	39.9
			76.3
Freshwater Forested/Shrub	30	ALFA	0.9
	30	MSDI	1.3
	30	MSND	9.2
	30	STTE	7.5
	40	ALFA	57.8
	40	FSDI	4.7
	40	HIHR	6.8
	40	MORA	10.5
	40	STTE	361.1
	40	SUROU	7.5
	40	VAFO	21.7
	80	BRRI	300.2
	80	FLPL	391
	90	FLPL	39.1
	90	HIHR	82
	90	HILR	26.6
			1590
Lacustrine Freshwater Pond	10	GLCR	0.6
	10	MTRUG	15.6
	30	MSDI	0.2
	40	MORA	10.4
	40	SUROU	0.1
	40	VAFO	4.6
	80	FLPL	0.7
	90	HIHR	20.7
	90	HILR	0.7
			31
Lacustrine Lake	40	MORA	1.9
			2.1
Riverine	30	ALFA	5.8
	30	MSND	30.8
	30	RAVI	6.3
	30	STTE	6.8
	40	ALFA	20
	40	HIHR	4.1
	40	STTE	39.3
	40	SUROU	1.2
	80	BRRI	518.3
	80	FLPL	20.6
			1705.8
Total wetlands			**5694.2**

Please see the following links for spatial and attribute data for non-federal wetlands described and mapped by the NRCS:

http://www.kenaiwetlands.net/

http://WWW.KENAIWETLANDS.NET/SEWARD/index.HTM

http://WWW.KENAIWETLANDS.NET/SEWARD/SewardPlantCommunities.htm

http://WWW.KENAIWETLANDS.NET/SEWARD/Ecosystems/Intro.htm

http://WWW.KENAIWETLANDS.NET/SEWARD/MUdescriptions/MUsummary.htm

http://WWW.KENAIWETLANDS.NET/MUsummary.htm

Hydrology

Analysis of current conditions in the Resurrection River watershed focuses primarily on the portion of the watershed on US Forest Service lands. Stream channels in much of the Resurrection River watershed on Forest Service lands are minimally impacted by human uses and are in their natural conditions, as much of the watershed is relatively inaccessible backcountry. Stream channels that are impacted by human uses are generally within about ¼ mile of roads or trails. Current conditions on non-Forest Service lands in the western and southern portions of the watershed are also considered in this analysis as they relate to processes in the watershed as a whole. While most of the western portion of the watershed is undeveloped backcountry, the southern portion of the watershed is adjacent to the highly developed areas in and around Seward.

Geomorphologic Trends

Valley morphology, stream channel morphology, and morphologic processes in the Resurrection River watershed are largely controlled by glacial processes, high relief terrain, and high precipitation. High sediment loads from glacial sources control the channel morphology of the Resurrection River. Extremely high stream flows per square mile of drainage area, resulting from steep watersheds and high precipitation, result in frequent dynamic channel changes in many of the tributary streams to the Resurrection River.

Glaciers and ice fields in the watershed have been receding and thinning for the past 200 years. Since about 1815, when the Exit Glacier nearly reached the Resurrection River during the Little Ice Age, the glacier has receded approximately 1.25 miles to its current location (National Park Service, 2010). Cusick (2001) compiled evidence from aerial photography and dendrochronology showing variable rates of recession over the past 200 years, averaging 43 feet per year, but greatly accelerating in the late 19th Century and early 20th Century. Vegetative succession is occurring in areas recently exposed by glacial recession. Despite glacial recession, Exit Glacier continues to produce abundant sediment, resulting in a dynamic outwash channel in the Exit Glacier outwash stream.

High sediment loads created from glacial sources result in aggradation of gravel in the valley floor. Aggradation tends to occur in the lower Resurrection River outwash channels, as well as alluvial fans and glacial outwash zones of its glacial tributaries. Expansion of the outwash plain of the Exit Glacier has effectively dammed the Resurrection River just downstream of the Exit Glacier Road bridge. The outwash plain has pushed the river up against a bedrock wall and backwatered the Resurrection River channel upstream. Additional aggradation has occurred in this low energy, low gradient section of the

Resurrection River, resulting in decreased clearance under the Exit Glacier Road bridge. If this trend continues, the bridge will no longer have sufficient clearance to pass flood flows.

Upstream of the Exit Glacier Road bridge, the Resurrection River is still dynamic from glacial influence. Although much of the valley floor in this portion of the valley is forested, dynamic channel changes are common as a result of sediment deposition during floods. This can result in new channels cut through wooded areas, abandoned channels, and frequent channel obstructions. Non-glacial tributaries to the Resurrection River generally form alluvial fans where they encounter the valley floor. These alluvial fan channels are commonly dynamic, with constantly shifting channels.

Summit Creek drains a 6.5 square mile watershed and creates an alluvial fan on the broad pass separating the Russian River and Resurrection River. Because of its dynamic alluvial fan fed by glacial sediment, the Summit Creek channel has shifted between the Russian River and Resurrection River in the past century, and is currently part of the Resurrection River watershed (Figure 17). In the late 1950s, the Summit Creek channel migrated and began to drain into the Russian River watershed. Fearing that the increased turbidity and sediment loads would decrease ecosystem productivity on the popular Russian River, a levee was constructed in 1958 to force the flow of Summit Creek back into Resurrection River (Troyer and Medred, 1999). This levee and the bulldozer used to create it currently remain in place. The potential exists for a large flood to cause the channel to break through the levee, but as the glaciers continue to recede, sediment loads may decrease and the channel may become more incised into the alluvial fan.

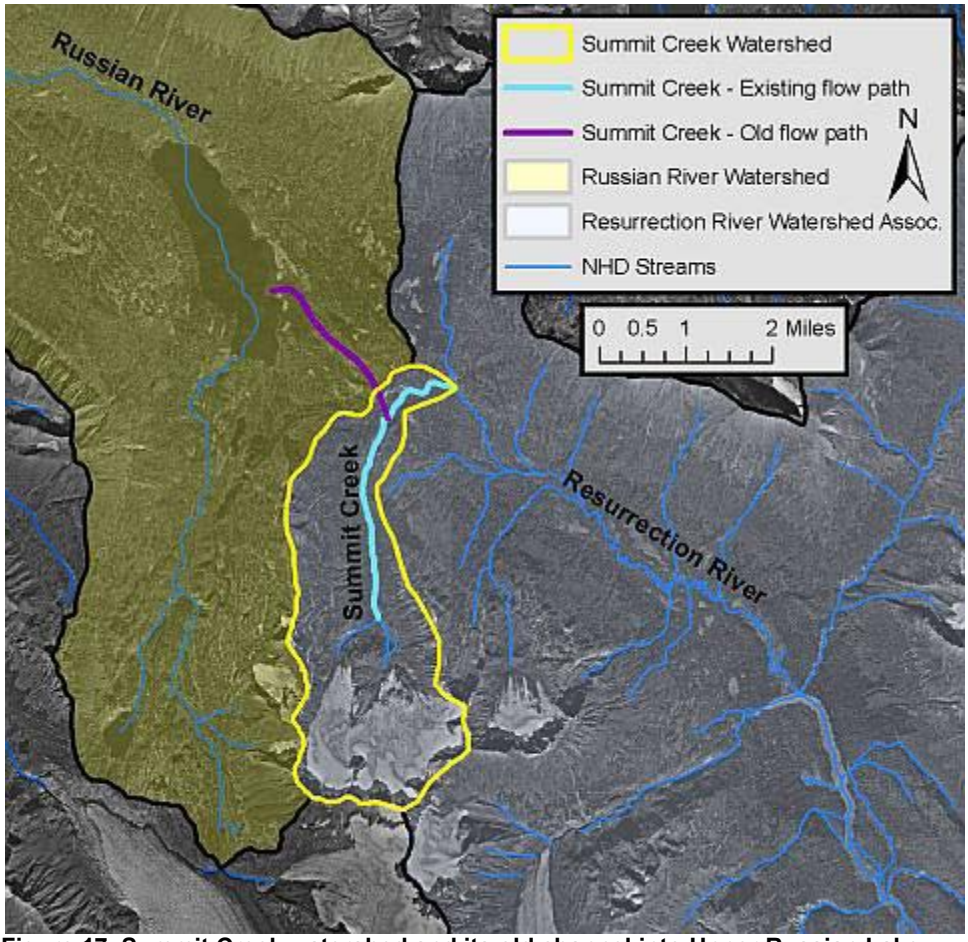

Figure 17. Summit Creek watershed and its old channel into Upper Russian Lake

Human Impacts to Water Resources

Impacts to water resources from human developments are relatively limited on US Forest Service lands within the Resurrection River watershed. Most of the impacts occur in the lower watershed in the area around Seward, along the Seward Highway, and along the Exit Glacier Road. Human impacts to water resources in the lower watershed include physical stream channel alterations and potential water quality impacts. Recreational uses have had limited effects on water resources in this watershed.

The course of the Resurrection River is controlled in places by roads, bridges, and other developments. The Exit Glacier Road acts as an artificial valley wall along the north/east side of the Resurrection River. The multiple braided channels in this active glacial outwash plain are constantly shifting as sediment is deposited and transported. The road bed cuts off some of the available valley floor and floodplain for this dynamic channel, but overall has little effect on the function of the Resurrection River channel. Channels of the Resurrection River currently flow up against the road bed in 5 areas, in some places requiring riprap to stabilize and protect the road. These are areas where riparian vegetation would normally provide stabilization and habitat. The Exit Glacier Road also interrupts the natural flow of tributaries into the floodplain of the Resurrection River. Some tributaries are forced to flow parallel to the road until they reach the fixed location of a bridge.

Two major bridges cross the Resurrection River. The upstream bridge is on the Exit Glacier Road. As discussed previously, this bridge has low clearance as a result of aggradation of sediment upstream of the Exit Glacier outwash fan. This bridge also limits the ability for the channel to naturally migrate. The downstream bridge is on the Seward Highway near Seward. At this point, the channel occupies multiple channels, and the multi-span bridge provides adequate width for the channel. However, the fixed location of the bridge, as well as development in this area, do not allow for any natural channel migration that would occur under natural conditions.

Bank erosion from human sources is relatively limited on the National Forest System lands of the watershed. This river system receives very little fishing pressure because of its high sediment loads, and angler trampling from fishing access is not a large concern. Other recreational uses only have localized effects on streams in the watershed where the infrequently used Resurrection River Trail crosses streams. Human-caused bank erosion increases downstream toward Seward, where erosion is associated with development and along roads in the Seward area. Because bank erosion rates are naturally high on the Resurrection River as a result of its high sediment loads and dynamic nature, any artificial sources of bank erosion have little impact on the overall stream channel condition or water quality.

Flood control berms artificially control the streamcourses of some tributary streams such as Box Canyon Creek and Japanese Creek. Levees have been constructed along the lower portion of Box Canyon Creek since at least the 1980s to prevent flood flows from inundating developed areas in the historic floodplain to the southeast and to direct Box Canyon Creek beneath the Exit Glacier Road and into Resurrection River. Because this is an alluvial fan system that transports large amounts of sediment, this levee requires constant maintenance to maintain its function. Continued aggradation further increases the risk of high flows overtopping the levee and increases the maintenance needs. A portion of this levee lies on National Forest System lands. Similarly, the stream course of Japanese Creek is controlled by levees to mitigate the effects of flooding and protect communities in the Seward area. These levees are not on National Forest System lands.

The lower portion of the Resurrection River channel, adjacent to Seward, is impacted by a variety of stressors. Extensive development has led to reductions in available floodplain widths for many streams as a result of roads, railroads, housing developments, and flood control levees. Many of the streams near Seward carry high bed loads and naturally migrate across wide outwash plains or alluvial fans.

Development in these areas is highly susceptible to erosion as these stream channels adjust. Gravel mining just upstream of the Seward Highway bridge provides a self-replacing gravel source for the community, but disrupts flow patterns. Mining operations do not greatly alter the natural channel function, largely because of the high levels of bedload sediment transported by the river. Further downstream, the Resurrection River flows up against a large berm on which lies the airport, restricting any capacity for the river to migrate to the west. An artificial gravel berm currently separates flows in the Resurrection River from flows in Salmon Creek where these two stream courses converge at the head of Resurrection Bay.

Impacts of Channel Changes and Flooding

Impacts to human developments associated with channel changes and flooding in the Resurrection River watershed occur primarily in the lower watershed on non-National Forest System lands, where extensive development has occurred in floodplains and other low topography areas. As the magnitude and frequency of flood events have increased with changing climate and more of the area is being developed, more problems are associated with flooding and channel changes. Recent major flooding episodes in the Seward area have occurred in 1986, 1989, 1995, 2002, and 2006 (Seward/Bear Creek Flood Service Area, 2007).

The floods of October 1986 occurred after a storm dropped over 15 inches of rain on the Seward area over the course of 24 hours (Jones and Zenone, 1988). A landslide temporarily dammed Box Canyon Creek in its narrow canyon, causing a large outburst flood to occur once the dam released (Jones and Zenone, 1988; Department of the Army, US Army Engineer District, Alaska, 1992). This flood broke through the levee and washed out the Exit Glacier Road, and Box Canyon Creek re-occupied an abandoned channel connecting to Salmon Creek through developed areas to the east. Because of its high sediment loads and potential for flooding, particularly with the potential for additional landslide dam-burst floods, maintaining this levee to keep Box Canyon Creek from flowing into this abandoned channel has been a challenge that requires continual resources in order to protect developed areas.

Additional impacts have occurred on Forest Service lands as a result of flooding and channel changes. Flooding during the 1995 floods caused extensive damage to the Resurrection River Trail and its bridges over tributaries to the Resurrection River. Much of the trail damage from these floods in the upper Resurrection River watershed is the result of trails being located within floodplain areas, and much of this damage has not been repaired. Flooding in 2002 caused the Martin Creek Bridge on the Resurrection River Trail to wash out. This bridge has not been replaced to date, limiting trail access to the upper watershed. The centerline of the Resurrection River delineates the legal property boundary between National Forest System lands and National Park Service lands. Because of the dynamic nature of the Resurrection River, this property boundary periodically has to be updated, resulting in gain or loss of National Forest Service land area.

Frequent flooding events in the Resurrection River watershed often cause inundation of city, borough, state, and private property in the Seward area. Because much of downtown Seward was constructed on the Lowell Creek alluvial fan, a diversion tunnel was built in the 1940s from the mouth of the canyon to the head of Resurrection Bay to protect the town. Additional development now exists on the alluvial fans of Lost Creek, Box Canyon Creek, Sawmill Creek, and Spruce Creek. These alluvial fans are all fairly active because these streams generally carry high sediment loads during floods. Dynamic channel shifting can occur at the apex of an alluvial fan, causing new channels to develop far from the previous active channel. Flood events often result in emergency construction of levees to protect property, as well as extensive work to remove sediment and debris that has been deposited in developed floodprone areas. Flooding in the Seward area also causes physical loss of property and damage to roads, the railroad, and

other infrastructure. Impacts to water quality during flood events can include the release of oil, gas, and other toxic chemicals associated with urban and industrial development.

Efforts are underway to mitigate some of the effects of flooding in the Seward area (Seward/Bear Creek Flood Service Area, 2007). Removal of debris and bedload from key areas may help temporarily increase bedload conveyance and reduce the impacts of flooding. Keeping culverts along the Exit Glacier Road clear of debris can help prevent damage to the road. Developing a coordinated approach to gravel removal operations along the lower Resurrection River may help issues with flood conveyance. Collecting hydrologic information about channel processes on many of the area streams will help inform additional mitigation measures.

Limiting development in floodprone areas is the most effective way to mitigate the effects of flooding in the area. This is difficult because much of the existing development is located on alluvial fans of active, high bedload stream channels, and few alternate locations exist for construction. The Kenai Peninsula Borough recently updated the floodplain maps for the Seward area. A March 2009 ordinance enacted the Seward Mapped Flood Data Area (SMFDA), based on inundated areas from the 1986, 1995, and 2006 floods (Kenai River Center, 2010). Federal Emergency Management Agency (FEMA) flood insurance rate maps, last revised in 1981, were also recently updated using 2006 data and released to the public in 2010. Although updated floodplain data will better regulate development in floodprone areas, the FEMA flood insurance rate maps may not reflect the current situation (Zemach, 2010) in part because frequent changes in flood elevations as a result of sediment deposition or scour are not always reflected on the most recent floodplain mapping. LIDAR data acquired in 2006 and 2009 for the area will be valuable for future updates of floodplain maps.

The proposed Seward Area Wetlands Functional Assessment Project and the Seward Area Suitability Mapping Project will better inform proper development in these sensitive areas around Seward (Kenai Peninsula Borough, 2010). These projects represent a partnership between the Kenai Peninsula Borough, the Kenai Watershed Forum, the Seward/Bear Creek Flood Service Area, and the Resurrection Bay Conservation Alliance to produce a wetlands management plan for the area, map flood hazards and channel migration zones, and put together recommendations for development in floodprone areas.

Climate

The climate of the Kenai Peninsula has been warming over at least the last several decades, a trend that is consistent with much of Alaska and other areas worldwide. Between 1949 and 2008, the mean annual temperature has increased by 3.1 degrees F in Anchorage, and 3.9 degrees F in Homer, with an average 3.1 degree increase statewide (Alaska Climate Research Center, 2009). Based on these datasets and the fact that coastal areas are seeing smaller temperature increases than interior areas, it is likely that the mean annual temperatures in the Resurrection River watershed have increased by 2 to 4 degrees F in the last 60 years. The largest seasonal temperature increases are the winter temperatures. Over the same time period, average winter temperatures have increased 6.3 degrees F in Homer, 6.8 degrees F in Anchorage, and 6.0 degrees F statewide (Alaska Climate Research Center, 2009). The degree of changing climate in the Resurrection River watershed is moderated by the marine influence of this coastal area. Climate warming and its effects in this watershed are likely less than what is observed in portions of the interior Kenai Peninsula, where annual precipitation is lower.

The effects of climate change on water resources in the Resurrection River watershed are not easily quantified, and data are not readily available to quantify changes in hydrology. However, climate change has had and will continue to have effects on the hydrology of the Resurrection River watershed. Perhaps the most dramatic hydrologic change occurring with climate change is accelerated melting of the glaciers and icefields on the western side of the watershed over the last several decades. Other hydrologic changes

associated with climate change include increased peak flows and increased flood frequency related to rain-on-snow events. Warmer winter temperatures are leading to more frequent winter rainfall, which can cause flooding in some situations. Changes in water quantity will be difficult to quantify in the Resurrection River watershed because no stream gauges are currently in operation. Changes to vegetative patterns in the watershed as a result of climate change are likely to be less dramatic than inland areas, and these changes are likely to have little effect on stream processes. Spruce bark beetle impacts are not common in this watershed because of the high annual precipitation and marine-influenced climate.

Vegetation and Ecology

To properly understand current conditions of the vegetation in the Resurrection River Landscape Assessment Area, one must first understand the successional pathways and disturbance regimes of south central Alaska.

Disturbance is defined as “any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment” (Helms 1998 p.49). Disturbance on the landscape is described by the amount of overstory removal. Major disturbance is described as stand replacing disturbance, whereas minor disturbance leaves some remnant overstory trees (Oliver and Larson 1996). Both of these types of disturbance shape the landscape in the Resurrection River drainage.

Avalanches, seasonal floods, wind events, and occasional fires could all be major disturbances in the Resurrection River drainage. Following a major disturbance, the typical successional pathway in this area would be for hardwoods (birch, aspen, or cottonwood) to initiate the new stand, then Lutz or Sitka spruce would typically begin growing in the understory. The hardwoods are fairly short-lived, and as they succumb to mortality, spruce becomes a dominant species in the forest canopy.

Spruce may remain as the dominant species in the canopy for a number of years, but when influenced by endemic levels of insects or disease, often the least vigorous trees succumb to mortality, which creates small gaps in the canopy. Hemlock is generally present growing beneath the spruce canopy and can persist in the understory for long periods of time until it is released by a gap created in the canopy. When the gap is created, the hemlock begins responding to the increase in light and will eventually grow to become a part of the canopy. In this way hemlock can become the dominant late seral species. In some stands, however, edaphic and climatic conditions are such that late seral species may never become dominant and spruce will remain the dominant species.

One of the most important disturbance agents causing a shift in canopy dominance from hardwoods to spruce is stem decay. “Stem decay fungi alter stand structure and composition and appear to be important factors in the transition of even-aged hardwood forests to mixed species forests. Bole breakage of hardwoods creates canopy openings, allowing release of understory conifers” (Lamb and Wurtz 2009, p. 53).

Among the softwoods, the principal biotic disturbance agent continues to be the spruce bark beetle (*Dendroctonus rufipennis*) which affects spruce. Other biotic disturbance agents include other bark beetles, animals, people, various rots, and occasionally defoliators. These other biotic disturbance agents are a small contributor to change within stands of softwoods in this area.

Abiotic disturbance agents are constantly at work and affect a wide variety of stands. Avalanches generally follow avalanche chutes and act on a stand to maintain shrubs or early seral hardwoods in a stand. Wind generally causes disturbance in mature stands. Fire generally has the most significant effect on spruce stands. Seasonal flooding may affect any stand within the flood plain of a stream or river.

Botany and Weeds

Non-native Plants

In general non-native plants on the Chugach National Forest are restricted to areas of human disturbance and have been observed in Kenai Peninsula surveys (Duffy 2003). Important factors affecting non-native plant populations appear to be the high level of human use, the diversity of human use (including the use of pack animals, mountain biking and other means of mechanical recreation), and the change in natural communities due to road construction, and re-vegetation projects. All of these factors are projected to increase over time.

Inventories for non-native plants within the Resurrection River landscape area have taken place in select areas over the past 10 years. Past inventories include roads, trailheads and trails and have focused on areas of human disturbances, which is where most non-native species are found. The majority of the Resurrection River landscape area remains undisturbed by human activities and should be free of non-native species. Areas of human disturbance include roads (Seward Highway and Exit Glacier Road), trails and trailheads (Resurrection River Trail), and other developments such as the National Park Service site at Exit Glacier. Figure 18 shows locations of non-native plants from various inventories.

The existing data shows that the most commonly encountered non-native plant is the common dandelion, followed by the common plantain. There are also several species that were only encountered once. The following table displays non-native species documented from past inventories from most common to least common. There are also 85 records with no non-native species present.

Table 13. List of non-native plants found in the analysis area

Scientific Name	Common Name	Count
Taraxacum officinale F.H. Wigg. ssp. officinale	common dandelion	274
Plantago major L.	common plantain	79
Trifolium repens L.	white clover	38
Phleum pratense L.	Timothy	20
Melilotus officinalis (L.) Lam.	yellow sweet clover	17
Lolium perenne L. ssp. perenne	perennial rye grass	16
Linaria vulgaris P. Mill.	butter and eggs	15
Poa annua L.	annual bluegrass	14
Matricaria discoidea DC	pineappleweed	11
Medicago sativa L. ssp. sativa	alfalfa	10
*Leucanthemum vulgare Lam.**	ox-eye daisy	7
Poa pratensis L. ssp. irrigata (Lindm.) H. Lindb. and Poa pratensis L. ssp. pratensis	spreading bluegrass and Kentucky bluegrass	7
Crepis tectorum L.	annual hawksbeard	6
Rumex acetosella	sheep sorel	5
Trifolium hybridum L.	alsike clover	5
Trifolium pratense L.	red clover	5
Ranunculus acris L.	tall buttercup	3
Alopecurus pratensis L.	meadow foxtail	2
Bromus inermis Leyss.	smooth brome	2
Neslia paniculata (L.) Desv.	ball mustard	2
Rumex crispus L.	curled dock	2
Anthemis cotula L.	mayweed, stinking chamomile	1
Brassica rapa L.	field mustard	1
Hordeum jubatum L.	foxtail barley	1

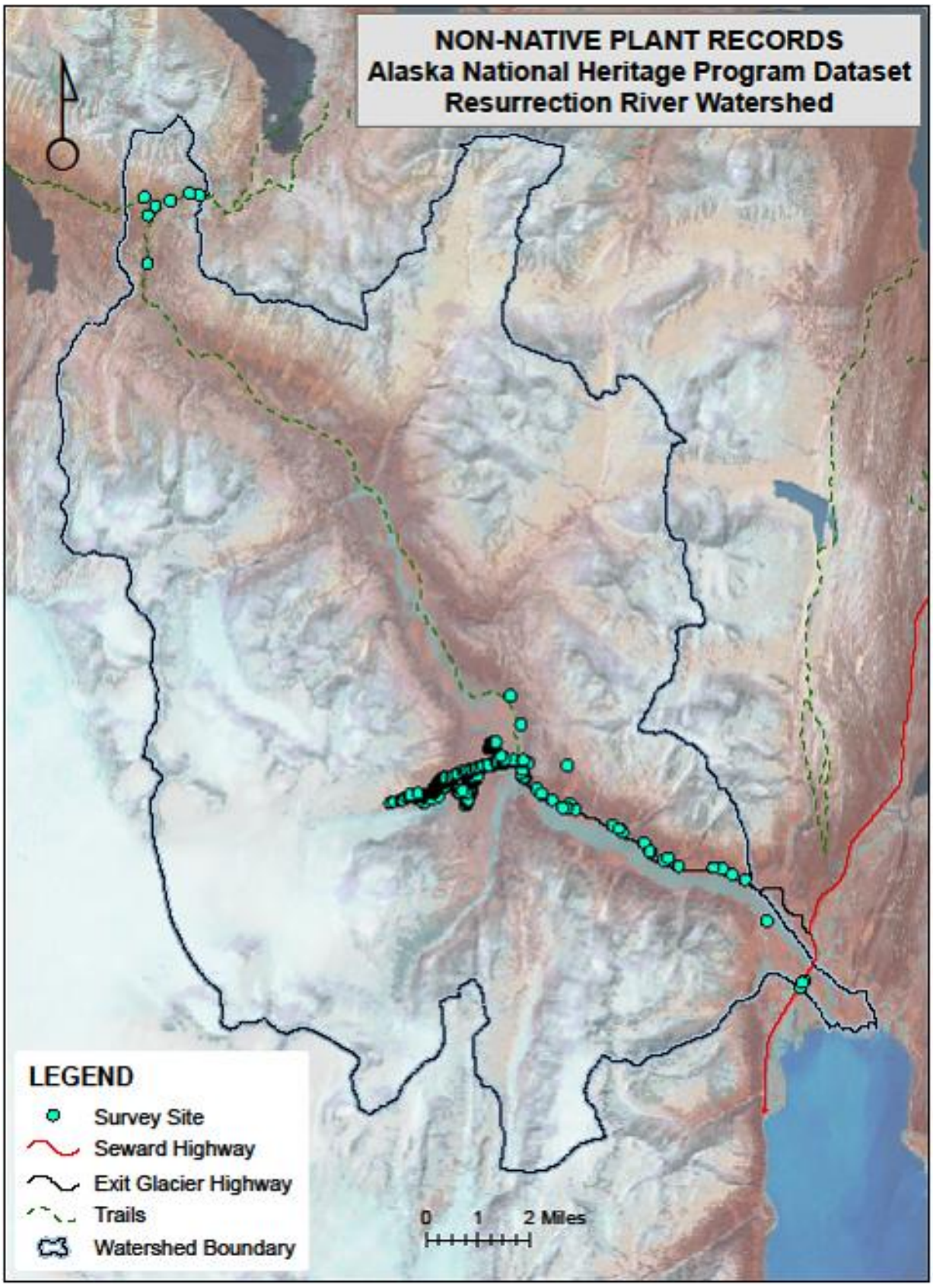

Figure 18. Map displaying known locations of non-native plants

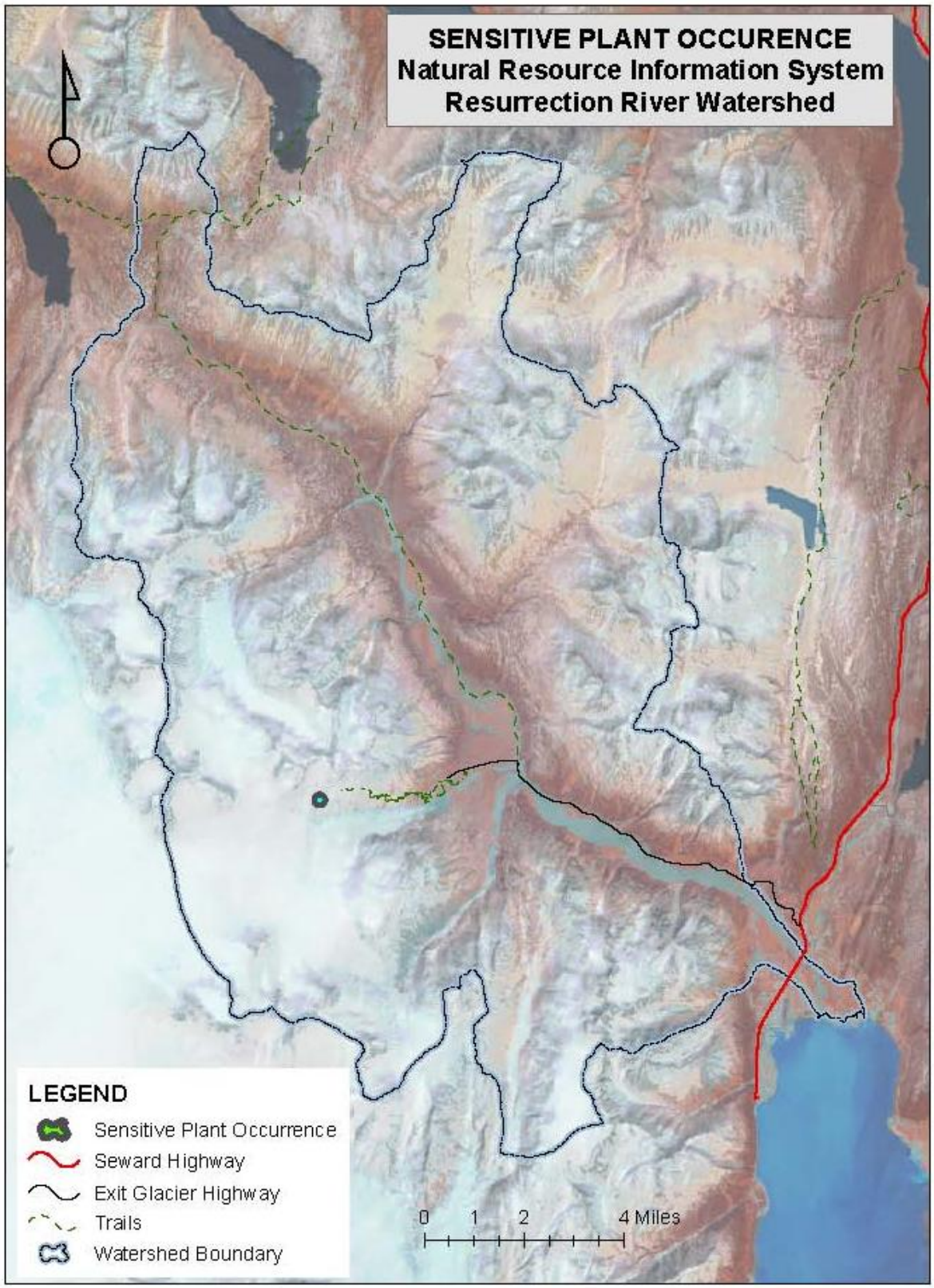

Figure 19. Map of sensitive plant occurrence in the analysis area

Sensitive and Rare Plants

Sensitive plants, like other plants, are influenced by various biological, chemical, and physical environmental gradients or regimes. A habitat diversity/ bioenvironmental model combining bioclimatic, landcover, and landtype GIS database layers into a single GIS layer was developed to identify and model various bioenvironmental regimes for sensitive plants (DeVelice et al. 1999). This bioenvironmental database was used to create maps of the potential distribution of all rare and sensitive vascular plants known or suspected to occur on the Chugach National Forest. However, the sensitive species list was revised in 2009 and new maps should be created to reflect the latest sensitive species list. There are five species on the Region 10 Sensitive Plant list potentially occurring in the Resurrection River Landscape Area. These include *Aphragmus eschscholtzianus*, *Cypripedium guttatum*, *Ligusticum calderi*, *Papaver alboroseum*, and *Romanzoffia unalaschcensis*. Of these, only the *Papaver alboroseum* has been found in or near the landscape area. There is also a nearby population of *Cochlearia sessifolia* that occurs along the coast. This particular species occurs in maritime beaches and would not be expected to occur within the landscape area.

The known sighting of *Papaver alboroseum* within the landscape area is located in an alpine area in the Kenai Fjords National Park and is shown in the following map. There is also a population of *Papaver alboroseum* found along Cooper Lake just outside the boundary of the landscape assessment area.

Fire and Fuels

The Resurrection River currently experiences heavy human use year round but is particularly busy during the summer months. Traffic can be quite heavy as travelers drive to Exit Glacier and to the Upper Resurrection River Trailhead. Additional activity in the drainage includes camping at Exit Glacier, a campground managed by Kenai Fjords, and dispersed camping along the Exit Glacier road on lands managed by the State of Alaska. This dispersed camping is of major concern from a fire management point of view as there can be in excess of 1000 people camped on both sides of the road over the Fourth of July holiday weekend. Due to this influx of visitors the Chugach National Forest currently has a forest order in place to prohibit any form of open fire source on agency lands along the Exit Glacier road.

The drainage can be characterized as Northern Pacific maritime forest as the species composition is comprised of species adapted to wet, cool, weather influences in the lower reaches and transitioning to drier ecosystems as one proceeds up the drainage to the north and west. The drainage experiences a variety of weather influences, most notably of which from a fire perspective is the constantly changing winds influenced by the topographical lay and features in the drainage and also its proximity to the Harding Ice field and the glaciers of Kenai Fjords. Winds in this drainage are extremely variable and can change quickly. There are three notable wind associated events which can take place here. They are as follows:

- Weather systems present in the Gulf of Alaska that moved in from the southern Pacific tend to funnel winds from the south into Resurrection Bay. They then hit land at Seward and travel north up the Salmon Creek drainage and spill over into the Snow River drainage or travel up Resurrection River to Resurrection Pass. Cooling as they rise, the winds then spill through the pass and flow down the Russian River to the north or down the Skilak River drainage and out across the peninsula to the west.
- Winds from the gulf can also be funneled into and through Cook Inlet on the west side of the peninsula and will flow in an easterly direction, traveling up the Kenai River and across the surface of Skilak Lake. From the Kenai they travel up the Russian River in a southeasterly direction, cooling as they rise, and then spilling down the Resurrection River to the southeast. This type of wind gathers speed as it flows down drainage and eventually spills out across Resurrection Bay. One effect to wind traveling across the Kenai Peninsula from the west is that much of the standing spruce that has slowed

wind speeds has been impacted by beetles. The drag effect on wind speed that had been there prior to the beetle impacts has been impacted as the standing timber has died and the crown cover has fallen to the ground. This overstory also acted to absorb sunlight and keep air temperatures down. As species such as Calimograstis grass have colonized the disturbed areas, much of the solar energy previously absorbed now contributes to warming of the air mass. Combined with moist air this warming contributes to thunder cell development and the potential for lightning. Skilak and Tustemena Lakes are large enough to contribute to this warming effect.

- The last major wind influence here is the cooling influences that take place near glaciers. The Resurrection River drainage is home to several glaciers whose origins begin in the Harding Icefield. The icefield cools the airmass over it and on calm days air spills down from the icefield and follows both open and glacier filled drainages down into the Resurrection River drainage. This form of wind is very unpredictable and could produce both unpredicted and unpredictable fire behavior. Afternoon winds from the glacier effect can reach speeds of 30 miles per hour and can severely impact fire suppression and fuels reduction activities. At the very least these winds could create serious impacts on the community of Seward if there was a significant source of smoke present.

The Resurrection River has experienced impacts from the latest cycle of spruce bark beetle infestation that started in the early to mid 1990s and proceeded through at least 2007. Estimates of total acreage affected by the latest infestation run as high as 1.4 million acres across the entire peninsula. Spruce stands impacted by beetles have been mostly confined to the upper reaches of the drainage several miles upstream from the Exit Glacier Bridge. The lower end of the drainage is inhabited by a different species of spruce which have not yet been impacted by beetles. Bark beetles have an impact on all spruce species and can result in tree mortality in all spruce species present; however, white spruce appears to be the most susceptible to major infestations with excess mortality being the end result. Initial impacts to fuels from beetle mortality result in a standing dead fuel model with intact trees loaded with dead needles. As the needles drop this aerial load decreases but the surface load will increase as fine fuels (needle cast and branches less than ¼ inch) accumulate. An additional effect of the initial beetle infestation is the introduction of fungus and other decay agents by beetles as they feed/burrow through the infected tree's cambium layer. These "incidental introductions" weaken the bole of the now standing dead snag, essentially causing the dead trees to fall apart over the course of several seasons. As the dead standing timber collapses the ground fuel load increases by several tons per acre. In addition to the increased fuel load created by the collapse of the spruce overstory, openings created increase the amount of sunlight reaching the ground surface. These openings are quickly colonized by disturbance dependant species like Calamagrastis grass, fireweed, and other annuals which add to the fuel load. In some stands fuel loadings can amount to 12+ tons per acre and generate very intense fire behavior and rapid rates of spread.

Current Fire Regime

Fire regimes are characterized by frequency, intensity, severity, forest types, and spacing of fire across landscapes patterns over time (Agee1994). Fire regimes help describe the role natural fire plays in the ecosystem.

Average recurrence intervals of large wildfires is infrequent and severe within the watershed. The time between fires is 200 years or more. Examples of vegetation in this type of fire regime (Fire regime V) are Pacific silver fir, western hemlock, mountain hemlock, subalpine, and alpine plant communities. About 60 percent of the watershed is Regime V. This does not include non forested areas of rock and ice.

Condition Class

At present, condition class mapping of the watershed within a given condition class is unavailable. Mid scale condition class mapping for Southwest Alaska has not been completed. Efforts at the forest level are proceeding and project level condition classes could be validated on a project by project basis.

Air Quality

Alaska periodically experiences air pollution from natural events including forest fires, volcanic eruptions and high wind glacial dust storms. Overall, however, Alaska residents enjoy a high degree of air quality. The municipalities of Anchorage, Fairbanks and Juneau have experienced degraded air quality due to automobile exhaust and wood burning for home heating.

Smoke, particularly from wildfires, has the potential to affect both local and regional air quality. Depending on its concentration, smoke from wildland fires can impact highway and aircraft safety, and affect visitor enjoyment. Fine particulate matter found in smoke can directly reduce local visibility and cause respiratory distress and disease in some individuals (NWCG 2001).

Fuel consumption and emissions are dependent on variables for ignition including fuel moisture, relative humidity, temperature, topography and wind speed. Predicted emissions from wildfire in the assessment area could be estimated using emission factors from First Order Fire Effects Model (FOFEM) during a given event.

Non-Attainment Areas near the Resurrection River

Ambient air quality standards (AAQS) are defined as maximum concentrations of pollutants present in the air at levels considered safe to public health and welfare. For each standard an adequate margin of safety is provided to protect sensitive members of the population, such as young children, the elderly and people suffering from illnesses. The National AAQS (NAAQS) were first established by the Clean Air Amendments of 1970. The municipality of Anchorage is a non-attainment area for particulate matter of 10 microns (PM-10) (EPA 2004). Additionally, the Resurrection River lies along the northeast boundary of Kenai Fjords National Park, which may be classified as a Class 1 airshed in regards to visuals and the impact smoke may have on them.

Foreseeable Impacts

Temporary and short-term visibility impacts can be expected in the immediate area during actual wildfire and would be affected by wind speed and direction. Drainage inversions will affect nighttime dispersal of smoke, with possible smoke effects 5 to 10 miles down canyon. Smoke from burning forest fuels can impact human health, particularly for the ground crews at the site.

Residents near the actual burn area may receive some respiratory discomfort; however, it is expected that most impacts will be in the form of nuisance smoke and/or smell. Smoke from the wildfire and the associated emissions would reside in the local airsheds a relatively short time depending on the weather and duration of fire. During the evening hours during a wildfire, some smoke would be expected to settle into the lower draws and drainages toward Anchorage, Cooper Landing, Seward, Moose Pass and the Sterling Highway. Some signing may be needed along roads to warn the public of smoky conditions. Smoke trapped in low-lying areas would be expected to dissipate when the nighttime inversion lifted.

Aquatic Species and Habitats

Resurrection River empties into Resurrection Bay which supports a large recreational sport and commercial fishery. In mid-August the city of Seward sponsors a “Silver Salmon Derby” which draws thousands of anglers into the area to attempt to catch some of the many thousands coho salmon, and many of these head for Resurrection River. The coho fishery of Resurrection Bay was supplemented with hatchery raised coho beginning in 1962 that were stocked into Bear Lake and additional stocking of coho into Resurrection Bay began in 1968 (Carlton 1990). Hatchery raised Chinook salmon smolts began to be released in 1970 and occurred annually starting in 1983, to supplement the Resurrection Bay Chinook fishery (Carlton 1990).

Little information exists for Resurrection River Watershed. The data available is in the form of the Anadromous Waters Catalog produced by Alaska Department of Fish and Game. The extent of distribution within the watershed may have changed over time and updates to the catalog may not be current. The Forest Service has not had the opportunity to survey the River to provide habitat features present within the watershed. Future opportunities exist for exploration of the area to determine the validity of the Anadromous Waters Catalog, habitat features available or needed.

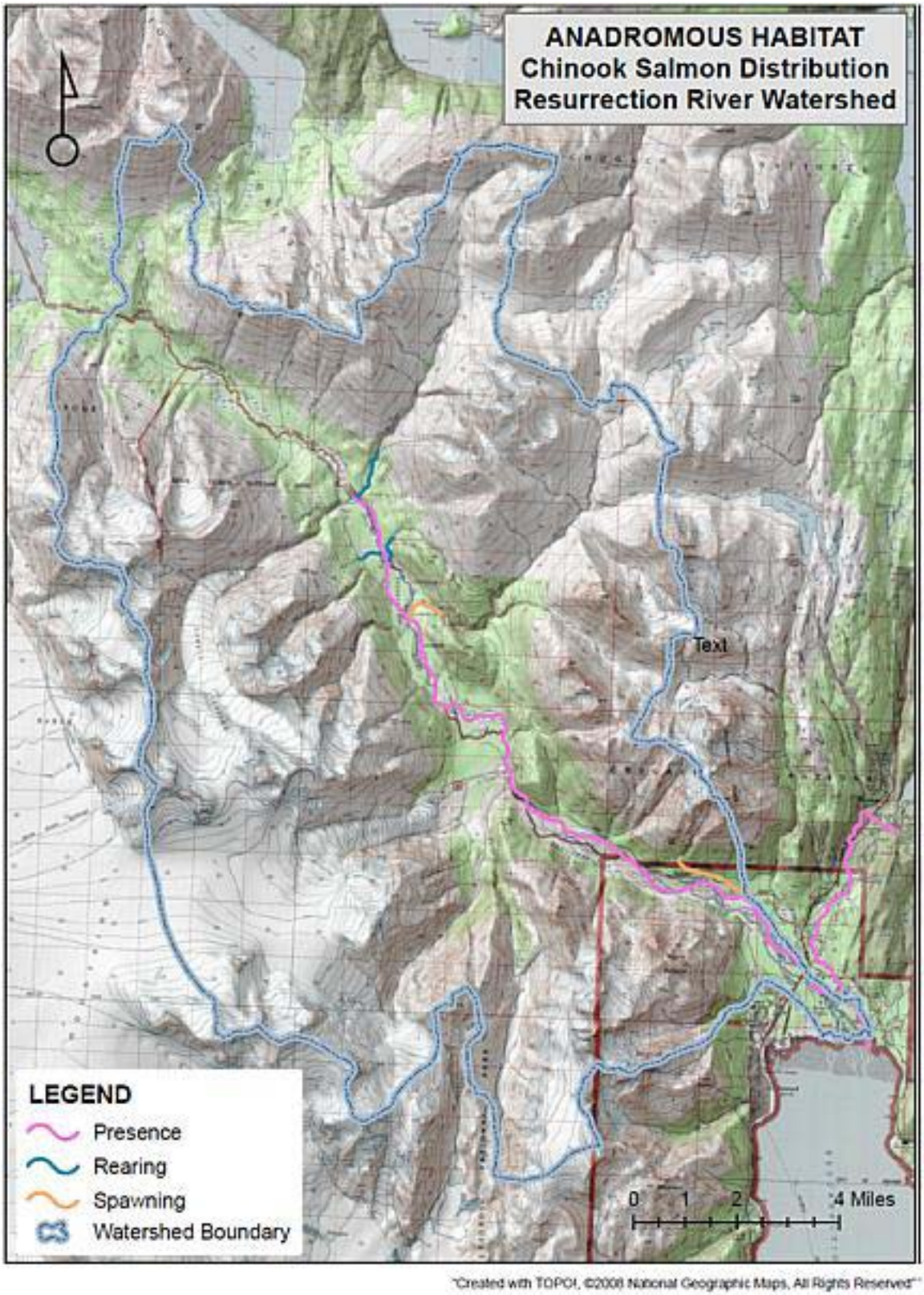

Figure 20. Chinook Salmon distribution within the Resurrection River Watershed as catalogued by the Anadromous Waters Catalog

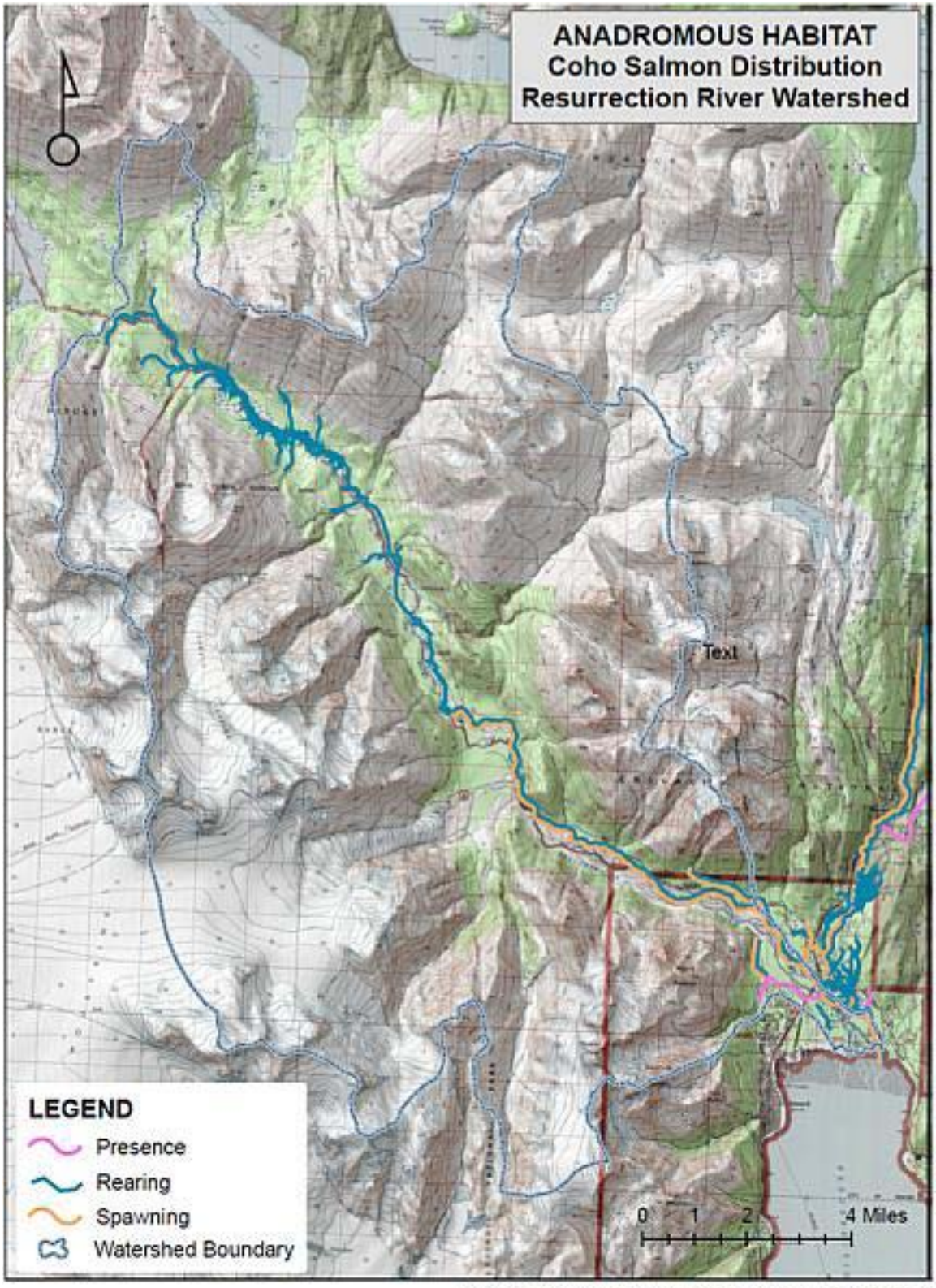

Figure 21. Coho Salmon distribution within the Resurrection River Watershed as catalogued by the Anadromous Waters Catalog

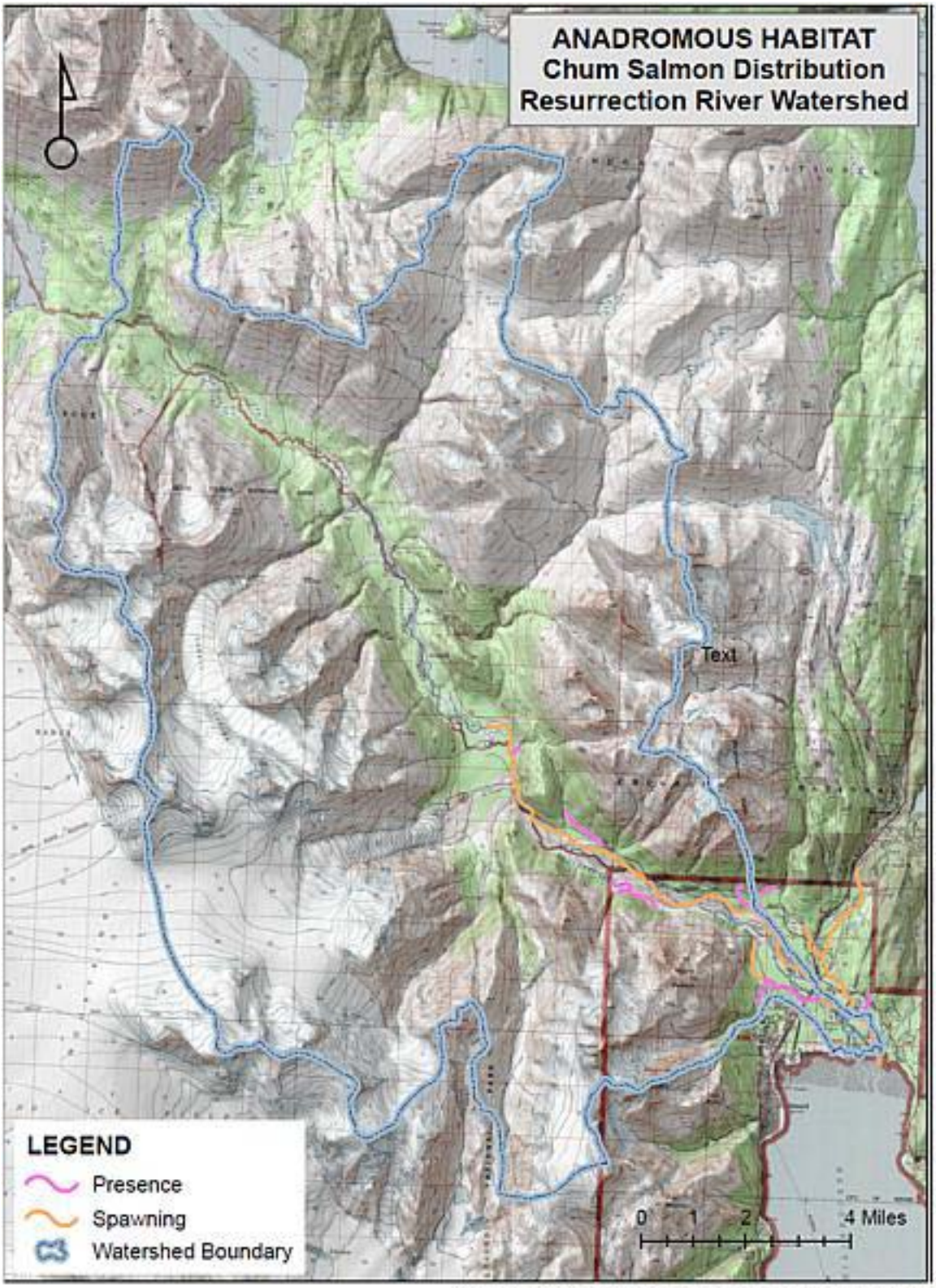

Figure 22. Chum Salmon distribution within the Resurrection River Watershed as catalogued by the Anadromous Waters Catalog

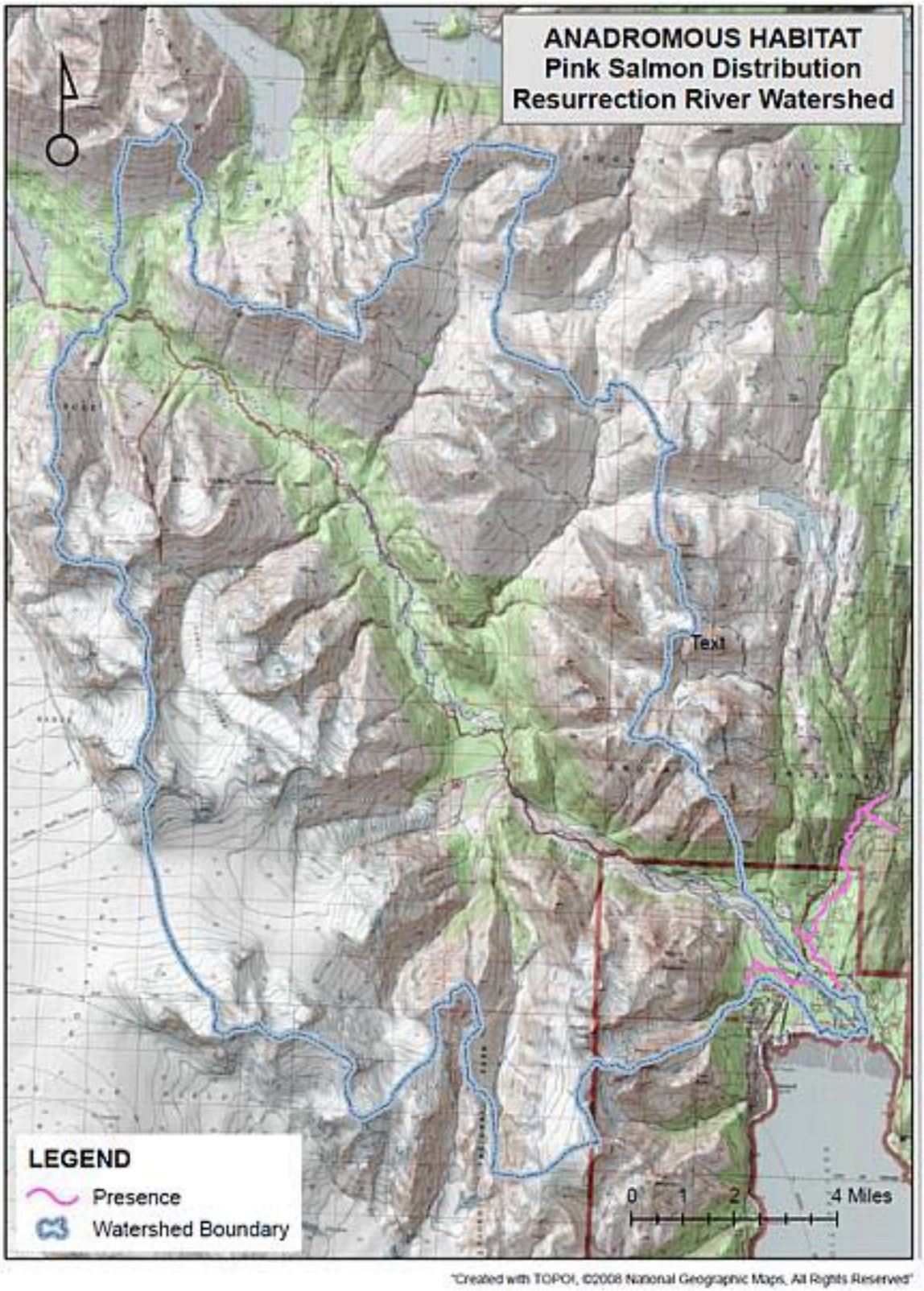

Figure 23. Pink Salmon distribution within the Resurrection River Watershed as catalogued by the Anadromous Waters Catalog

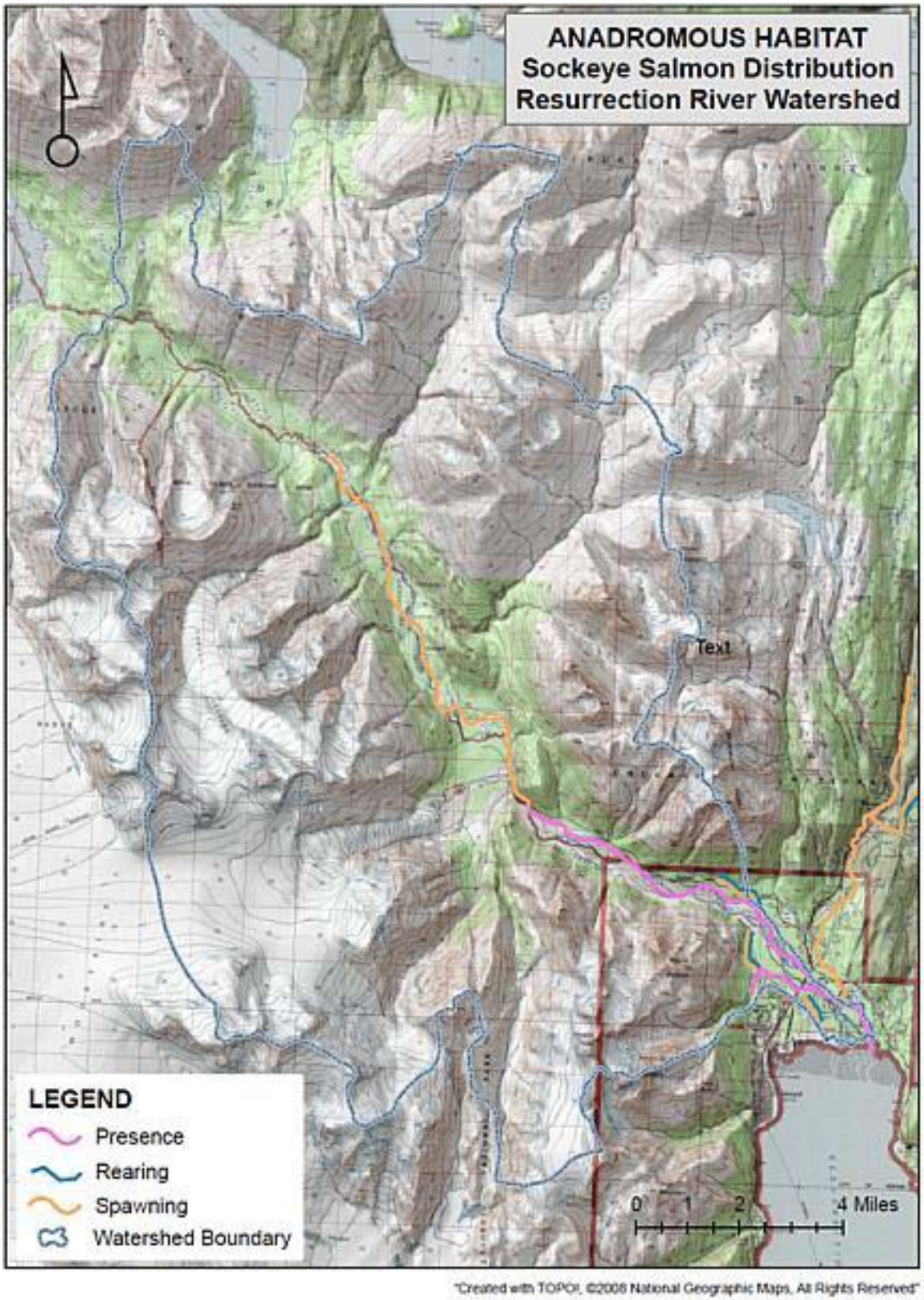

Figure 24. Sockeye Salmon distribution within the Resurrection River Watershed as catalogued by the Anadromous Waters Catalog

Terrestrial Species and Habitats

Current conditions came from USFS GIS and wildlife survey data, National Park Service (NPS) wildlife surveys, observations and studies. The USFWS provided some observation data. Wildlife sightings from the NPS in the Exit Glacier area are shown in Figure 25.

The Park Service notes that twenty nine species of terrestrial mammals occur or are expected to occur within Kenai Fjords National Park (AKNHP 2000). Habitats suitable for all or most of these species are present within the Exit Glacier area and presumably these species occur there with varying frequency. Most information regarding terrestrial species in this area has come from anecdotal reports by park staff and visitors and supported by a small number of surveys focused on bats and micro tines (Wright 2001), mountain goats (Tetreau 1989), moose (Everitt 2001) and a survey of furbearer occurrence and distribution (Martin 2001) completed in 2003.

Table 14 lists the existing and potential habitat for important species within the watershed, including Threatened, Endangered, or Sensitive Species (TES), Management Indicator Species (MIS), or Species of Special Interest (SSI). Existing habitat notes the species has been documented to occur. Potential habitat provides suitable habitat characteristics, although it is currently not known to be occupied by the species.

Table 14. Existing or Potential Habitat for TES, MIS, and SSI in the Watershed

Species	MIS	TES	SSI	Existing Habitat	Potential Habitat
Humpback Whale		X		YES	YES
Beluga Whale		X		NO	NO
Steller Sea Lion		X		YES	YES
Steller's Eider		X		NO	NO
Kittlitz's Murrelet		X		NO	NO
Dusky Canada Goose	X	X		NO	NO
Aleutian Tern		X		NO	YES
Black Oystercatcher		X		NO	YES
Brown Bear	X			YES	YES
Moose	X			YES	YES
Mountain Goat	X			YES	YES
Gray Wolf			X	YES	YES
Canada Lynx			X	YES	YES
Marbled Murrelet			X	YES	YES
Northern Goshawk			X	NO	YES
River Otter			X	YES	YES
Sitka Black-tailed Deer			X	UNKNOWN	YES
Townsend's Warbler			X	YES	YES
Wolverine			X	YES	YES
Bald Eagle			X	YES	YES

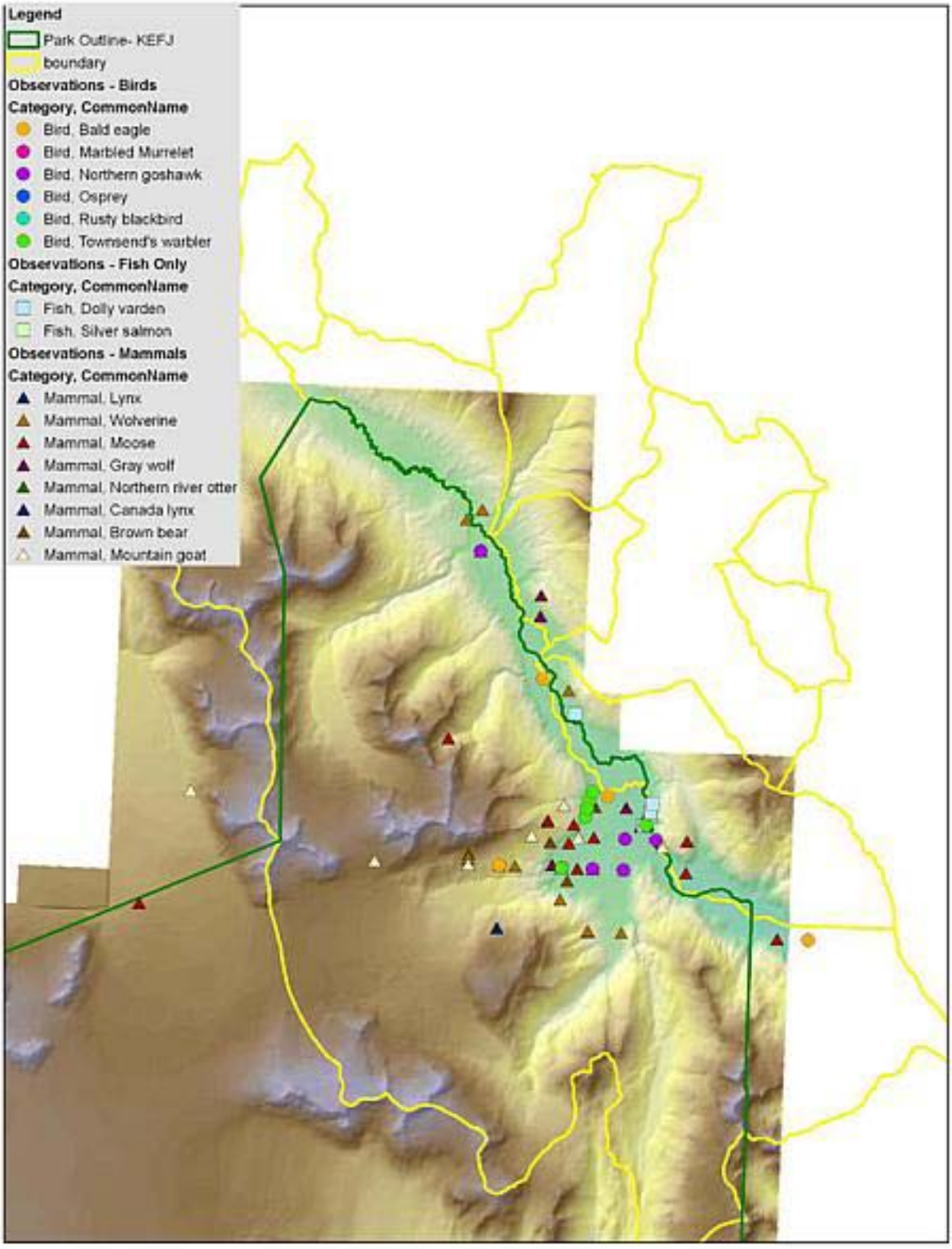

Figure 25. Wildlife Observations in Exit Glacier area from NPS species database

Threatened or Endangered Species

The Steller's sea lion (*Eumetopias jubatus*) is a threatened species with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands. They occur in Resurrection Bay and near the mouth of the Resurrection River at certain times of year feasting on herring and salmon.

The humpback whale (*Megaptera novaeangliae*) is an endangered species that occurs in all oceans of the world. They can be seen at times in Resurrection Bay and may occasionally forage near the mouth of Resurrection River.

Sensitive Species

The Aleutian tern (*Sterna aleutica*) is a Region 10 sensitive species that generally arrives at the Kenai Peninsula between 4–16 May. Fall migration begins shortly after individuals abandon colonies, typically in August. Staging sometimes occurs in coastal areas, but birds usually depart directly for the sea. Breeding colonies are restricted to coastal sites, typically located at heads of bays, reefs, permanent and ephemeral islands, estuaries in lagoons and at river mouths (Haney et al. 1991, North 1997). They often nest with Arctic Terns. Nests are a depression in vegetation, usually on grassy or mossy flats, sand spits, sandbars, sand dunes, pebbly seacoasts, vegetated summits of flat-topped islands, reticulate and string bogs, wet coastal marshes, or tundra (Haney et al. 1991, North 1997). Colony locations frequently shift from year to year among traditionally used sites; as a result, local populations may fluctuate greatly (Haney et al. 1991). They usually forage in shallow water, including tidal rips, along rivers, over inshore marine waters, freshwater ponds and marshes, bays or fjord habitats.

Although they have not been documented to occur, potential habitat exists for them near the mouth of Resurrection River. A wetland area near the airport currently provides nesting habitat for Arctic terns, and potentially for Aleutian terns.

The black oystercatcher (*Haematopus bachmani*) is a Region 10 sensitive species. Completely dependent on marine shorelines for its food and nesting, this is a monogamous, long-lived bird. Breeding pairs establish well-defined, composite feeding and nesting territories and generally occupy the same territory year after year, often along low-sloping gravel or rocky shorelines where intertidal prey are abundant. Pairs nest just above the high-tide line and use the intertidal zone to feed themselves and provision their chicks. Diets of adults and chicks consist mainly of mollusks; principally mussels and limpets.

Black oystercatchers have not been documented in the watershed, but some potential habitat may exist near the coastline at the mouth of Resurrection River. Oystercatchers have been seen foraging in nearby areas of Resurrection Bay near the beach at Fourth of July Creek and towards Lowell Point.

Management Indicator Species

Moose

Moose are primarily associated with early to mid-succession habitat and riparian areas (USDA Forest Service, Chugach National Forest, 2002b) and are dependent on early seral vegetation types including young hardwoods (willow, birch, aspen and to a smaller extent, cottonwoods). The availability of winter range is the major limiting factor for moose population size. On the Kenai Peninsula, other limiting factors include predation, hunting, and mortality from vehicular collisions (Lottsfeldt-Frost, 2000). Renecker and Schwartz (1998) found that the distance between feeding and hiding/ thermal cover also can be a limiting factor, especially in areas of large-scale disturbance.

Chugach National Forest GIS data indicate that moose winter range exists on 2296 acres within the watershed, primarily Resurrection River adjacent to Exit Glacier Road (Figure 25). Areas which may provide important browse habitats occur on approximately 1,482 acres in stands classified as early seral aspen, birch, and in willow stands. Other areas in alder and conifer stands may be important for hiding and resting. Moose are surveyed infrequently by Alaska Department of Fish and Game in the watershed. The last survey occurred in 2005. Winter surveys have shown less than 50 moose over the last 40 years.

Kenai Fjords National Park reports that moose are present in the Exit Glacier and Resurrection River area year-round, but are most visible during winter. In fall and winter moose congregate between Exit Creek and Paradise Creek to browse on the concentrations of willow in the early successional forests. This area is considered critical winter habitat which may be key to the long-term survival of the local moose population.

The Alaska Department of Fish and Game considers the overall habitat on the Seward Ranger District to be of low quality and capable of supporting only 2 to 5 moose per square mile.

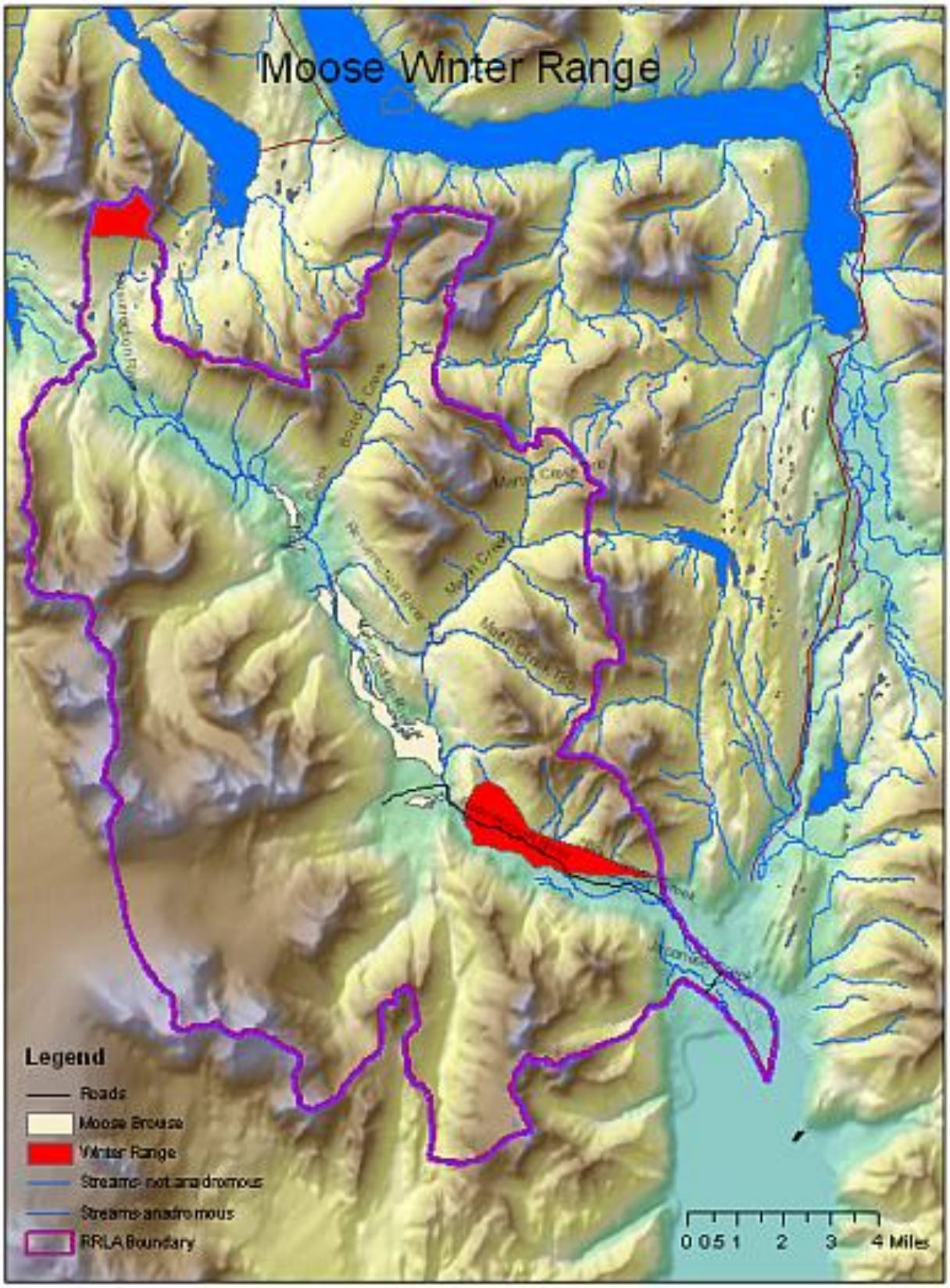

Figure 26. Moose Habitat

Mountain Goat

Mountain goats use cliffs, alpine, sub-alpine and old-growth habitats and are generally found near steep cliffs with slopes greater than 50 degrees. In Southcentral Alaska, winter habitat may be a limiting factor for mountain goat populations. They are also sensitive to low-level aircraft flights over summer alpine kidding habitats and wintering areas (USDA Forest Service 2002b).

Based on Chugach National Forest GIS data, mountain goat winter range primarily occurs on south-facing alpine slopes, spread throughout the watershed on approximately 3,064 acres (See Figure 27).

Goats are more abundant on the north side of the Resurrection River drainage than the south (west) side. ADFG reports that the numbers of goats north and east of the river have been stable at ~100 goats counted for over 30 years. On the south side of the river, goats have declined from >100 to <50 in the past 20 years.

Kenai Fjords National Park reports that mountain goats occupy nearly all of the steep and rocky high country around Exit Glacier. Goats can be seen throughout the year from Exit Glacier trails and the parking lot and are occasionally encountered at close range along the Harding Ice field Trail. Sporadic aerial survey efforts in Exit Glacier area (1981, 1985, 1990, 1991, and 1999) noted that potentially ~130 (1985 count) goats may be present in the western half of the Resurrection River watershed.

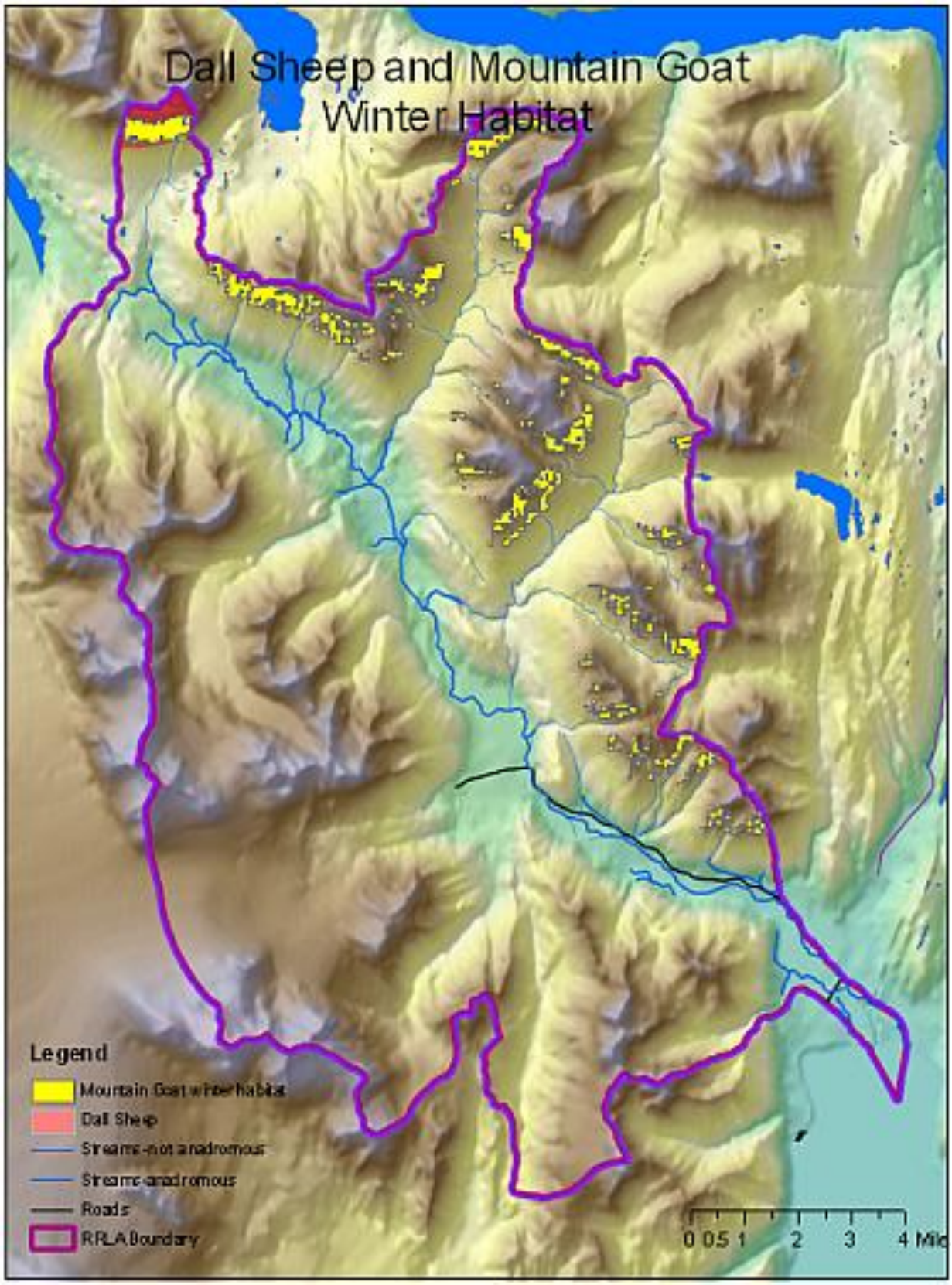

Figure 27. Mountain Goat and Dall sheep Habitat on Forest Service Lands

Brown Bear

Brown bears have large home range requirements and are generally intolerant of human activities and development. Suring et al (1998) estimated the Kenai Peninsula population at 280 bears, or about 12 bears per 386 square miles. This is an estimate and ongoing work collecting hair samples and analyzing DNA in cooperation with ADFG and USFWS will assist in updating population estimates in the future. Brown bears throughout the peninsula (units 7&15) have shown a positive growth rate over the past 15 years (personal communication with Thomas Mcdonough, Alaska Department of Fish and Game 2010).

On the Kenai Peninsula, the primary limiting factor is spring and summer feeding habitat. Spring and summer habitat includes south facing hillsides and avalanche chutes, big game winter ranges, and salmon streams that provide the high quality foods that bears need to develop fat reserves before denning and to replenish fat stores depleted after denning. Carrion, berries, and fish sources in the watershed provide a diversity of food sources for bears. The watershed contains numerous south facing slopes, avalanche chutes, winter range for moose, sheep, and goats, and five species of salmon in Resurrection River.

Brown bear winter habitat includes the core area, potential denning habitat, and post den emergence habitat especially for females with cubs (See Figure 28 and Figure 29).

Brown bear core exists on 13,612 acres Resurrection River (See Figure 29).

The best potential denning habitat was identified from a denning habitat model developed by Goldstein et al. (2010-in process of publication). This model predicts the probability of denning across the landscape. Brown bears may den on steep slopes throughout the watershed. Denning habitat is predicted to exist on 97,329 acres (30,473 acres with 80 percent probability, 66,857 with 100 percent probability) on steep slopes surrounding Resurrection River (see Figure 28).

Suring et al. (2005, pg 13-14) found when female brown bears with cubs leave dens, they are more associated with upland habitats in close proximity to cover. Suring's brown bear model determines the potential for habitat use in terms of probability. He estimates that the areas with a probability of 80-100 percent have the highest potential for use. This model predicts one small patch of about 32 acres near Resurrection River that meeting the criteria (See Figure 28).

In addition, Graves et al. (2007) reviewed GPS collaring data from brown bears collared between 1995 and 2002. The area reviewed covered 23,911 acres within the watershed, which is about 21 percent of the area. Of this, they found that 3,568 acres were not bear habitat, 5,929 acres were primary habitat, and 14,415 acres were potentially bear movement corridors (see Figure 29).

The Park Service reports that brown bears are infrequent visitors to Exit Glacier, typically passing through the valley in the spring and late fall. Brown bears are rarely observed around Exit Glacier in summer or fall likely due to the lack of salmon runs in local streams.

The effects of recreation on brown bears in the watershed are currently unknown. Recreation trails (Resurrection River Trail and Russian Lakes Trail) run through primary bear habitat, bear corridors (Graves 2007), and the core area. Campgrounds and recreation activities such as hiking, fishing, or mining occur near salmon streams where bears are known to forage (Resurrection River). The amount of recreation use and the numbers or trends in bear/human interactions are unknown. Flight seeing activities occur in the watershed and in over the core area, primarily flights on their way to view bears in Goat Creek and float planes headed for Upper Russian Lake. This activity is generally not managed by Forest Service permits, so the amount and effects on brown bears are unknown.

Roads and trails, other existing development, and increasing levels of recreational activities in the watershed may reduce the quality of available habitat and increase the number of negative bear-human encounters. On the Kenai Peninsula, habitat modification and human activities have resulted in an increase in the number of brown bears killed in defense of life or property (DLP) (Suring and Del Frate, 2002). During the summer, bears concentrate along low-elevation valley bottoms and coastal salmon streams in areas that are heavily used by people. Salmon congregate in Resurrection River and some of its tributaries (see fisheries section). Encounters may occur at salmon streams or along trails resulting in injury to humans and injury or death to brown bears. Aside from the increase in DLPs around the city of Seward, there are no trends in DLPs in the Resurrection River area.

Within Kenai Fjords National Park, bear encounters are reported and recorded. Records indicate bear interactions involving property damage; and encounters involving bluff charges, huffing, as well as all brown bear sightings in Exit Glacier area.

Table 15. Brown Bear DLPs from 2000-2009 around Seward

Year	Bears Killed in Defense of Life or Property
2009	0
2008	3
2007	1
2006	4
2005	3
2004	0
2003	0
2002	0
2001	0
2000	1

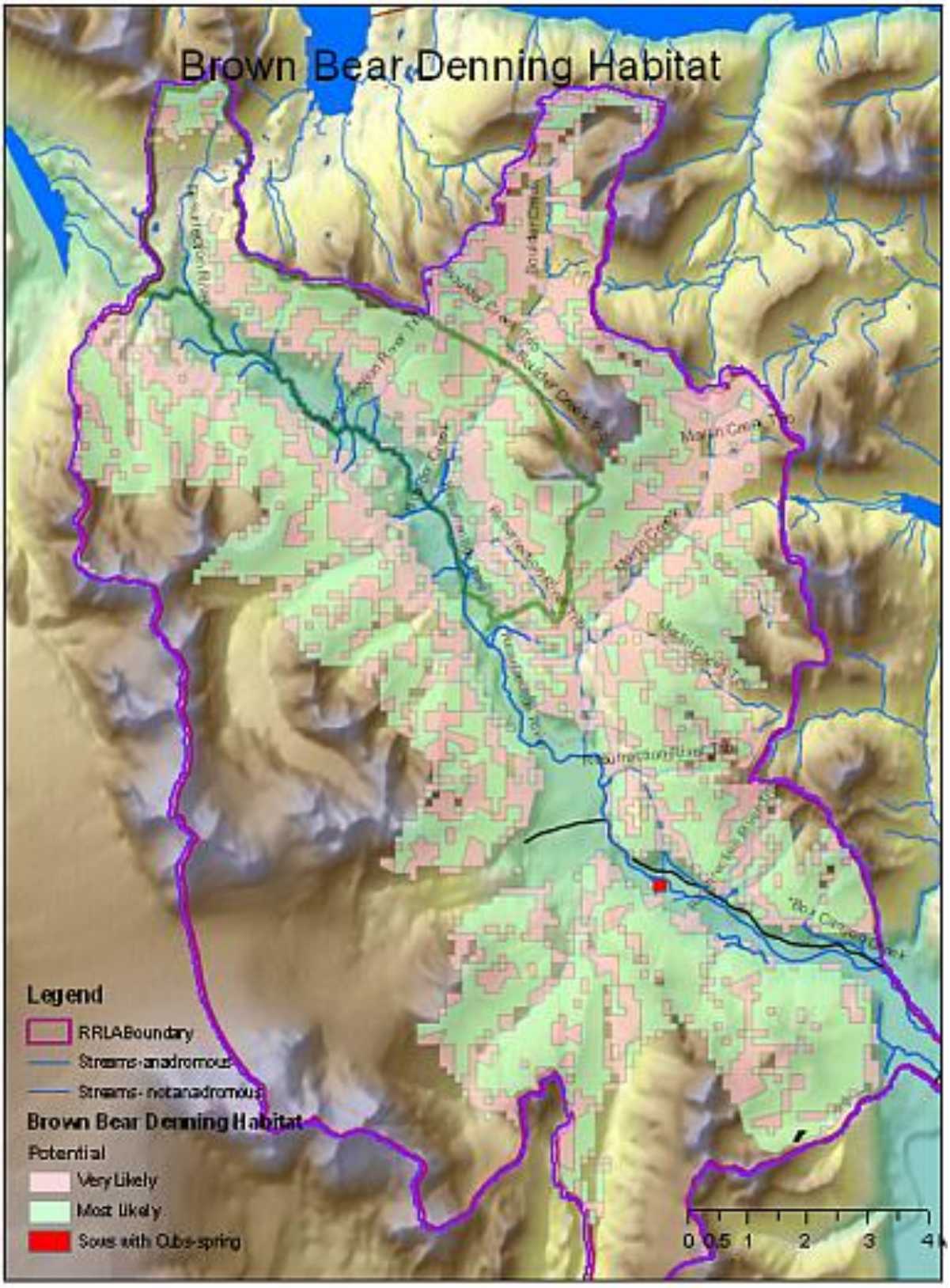

Figure 28. Brown Bear Denning Habitat

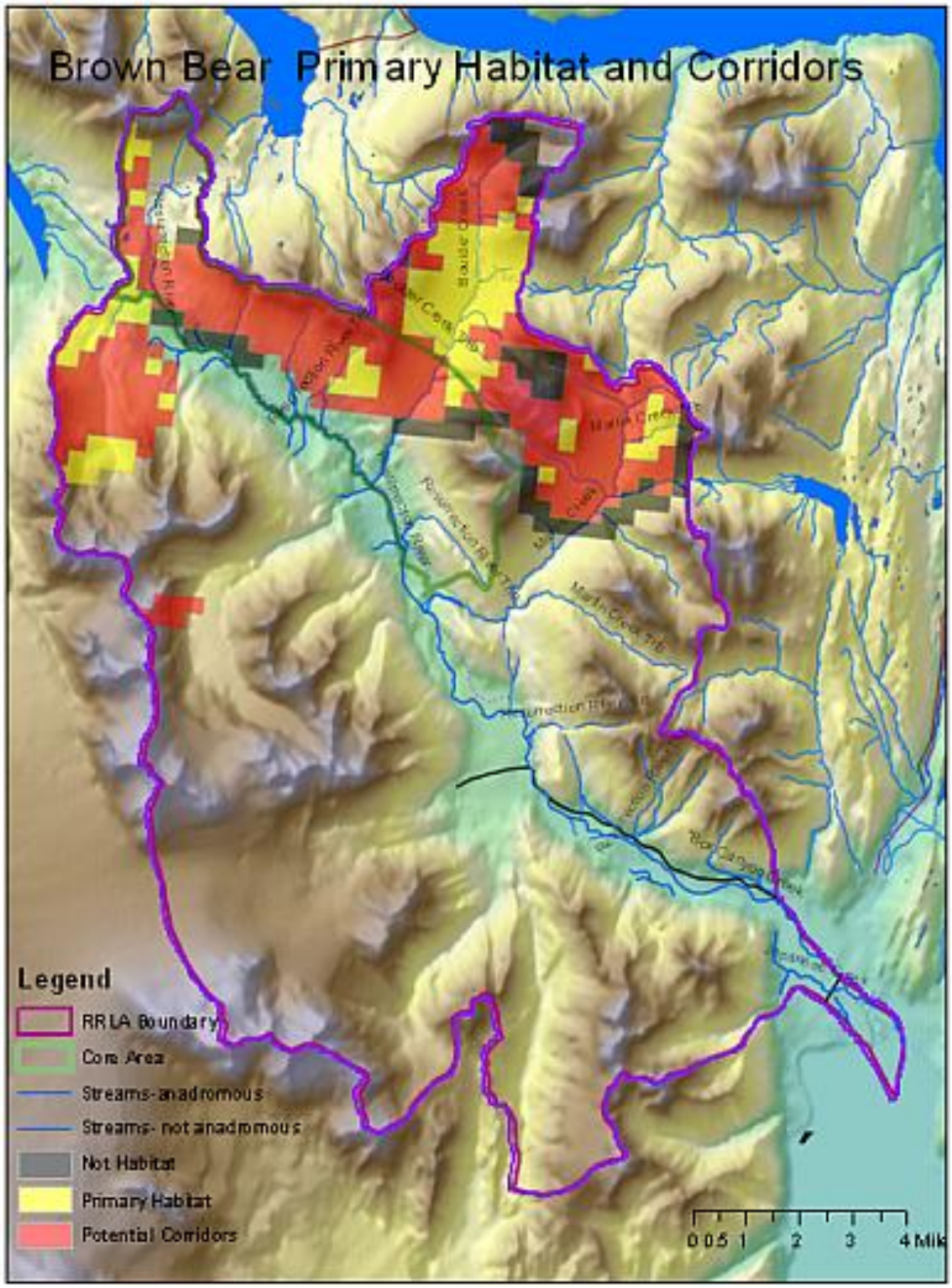

Figure 29. Brown Bear habitat Connectivity

Species of Special Interest

Bald Eagle

Bald eagles in Southcentral Alaska generally nest in old cottonwood trees near water and use the same nest each year (Daum, 1994). The proximity of large nest trees to food sources is the primary limiting factor for the bald eagle population. Approximately 80 percent of all bald eagle nests on the Seward Ranger District are in mature cottonwood trees with an average diameter of 31 inches and within one-quarter mile of an anadromous fish-bearing stream.

There are eight known bald eagle nests in the watershed, concentrated along Resurrection River and near the Seward airport (Figure 30). There are an additional 14 nests within 300 meters of the watershed boundary. Information on historic populations of bald eagles is not available. Habitat impacts, if they exist in the watershed, are likely related to natural disturbances such as flooding and human disturbance from recreation and aircraft.

The Park Service has not found bald eagle nests on NPS lands within the watershed.

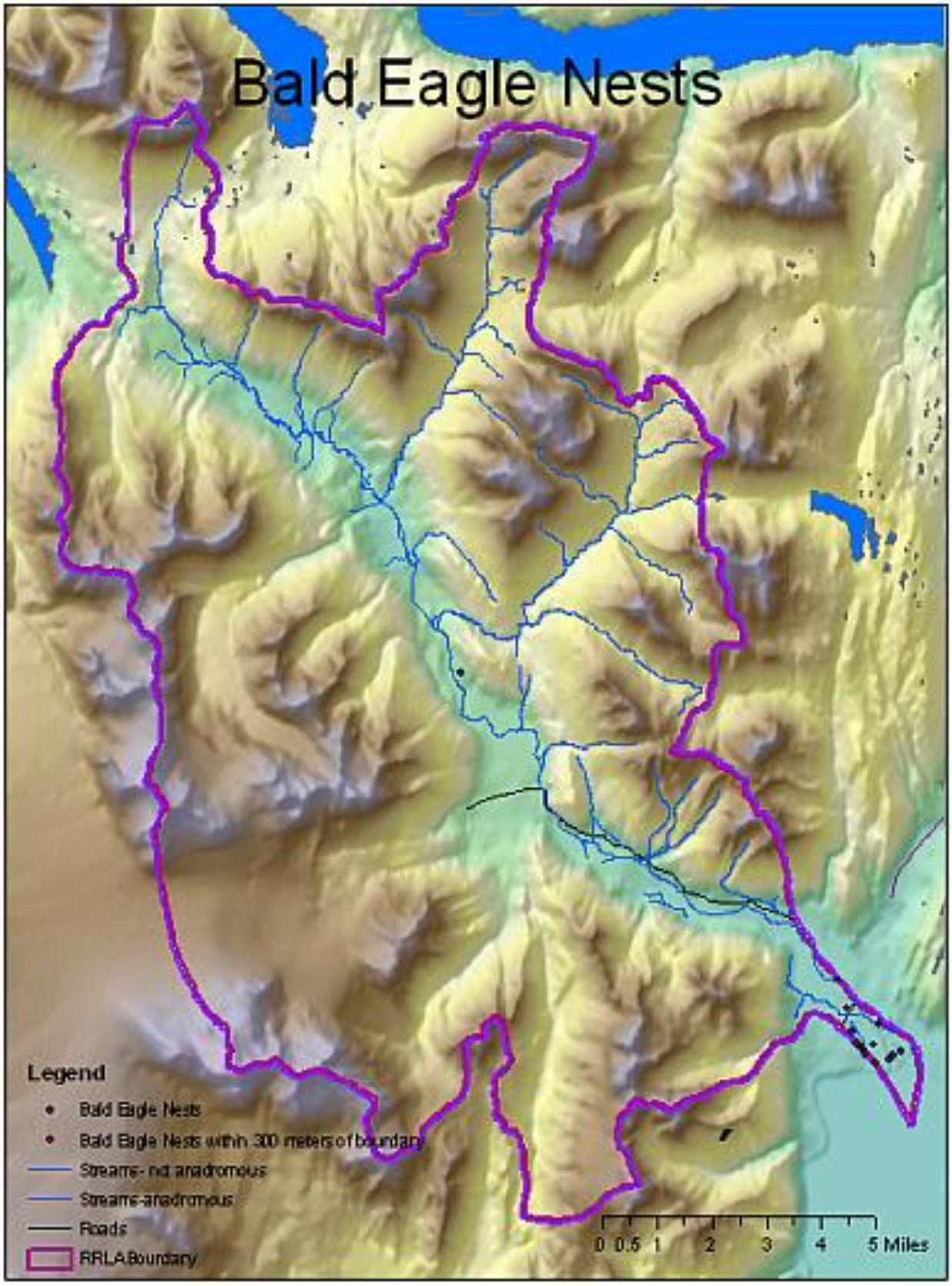

Figure 30. Bald Eagle Nests

Northern Goshawk

The northern goshawk is an uncommon forest raptor that feeds on small and medium sized mammals and birds (Iverson et al., 1996). They are year-round residents of the Chugach National Forest (USDA Forest Service, 1984). The amount and juxtaposition of feeding and nesting habitat appears to limit population viability in Southeast Alaska (Iverson et al., 1996). The nesting-breeding season is from March to July.

There are no known northern goshawk nests in the watershed. Surveys have not been conducted to determine if goshawks are present or breeding in the watershed, but potential nesting and foraging habitat exists. Goshawks have been noted by the Park Service around Exit Glacier and Boulder Creek.

The majority of goshawk nests on the Seward Ranger District are in old growth hemlock-spruce stands characterized by a closed canopy, large average diameter, gap regeneration, and an open understory (Seward Ranger District goshawk nest files). Approximately 80 percent of nests were in large hemlock or spruce stands with closed canopies. About 15 percent of nests were in pole sized birch stands and 4 percent were in large aspen/birch stands.

Using the stand classification of the Kenai Peninsula Borough, there are 2,540 acres that may offer potential nest habitat (See Figure 31). The majority of large conifer habitat is too open for nesting habitat, but goshawks might use the area for foraging. Potential habitat may exist in some of the stands of large aspen/birch stands and one large closed canopy hemlock/spruce stand in the northern part of the watershed. Opportunities exist to treat some of these areas to enhance potential habitat for the future.

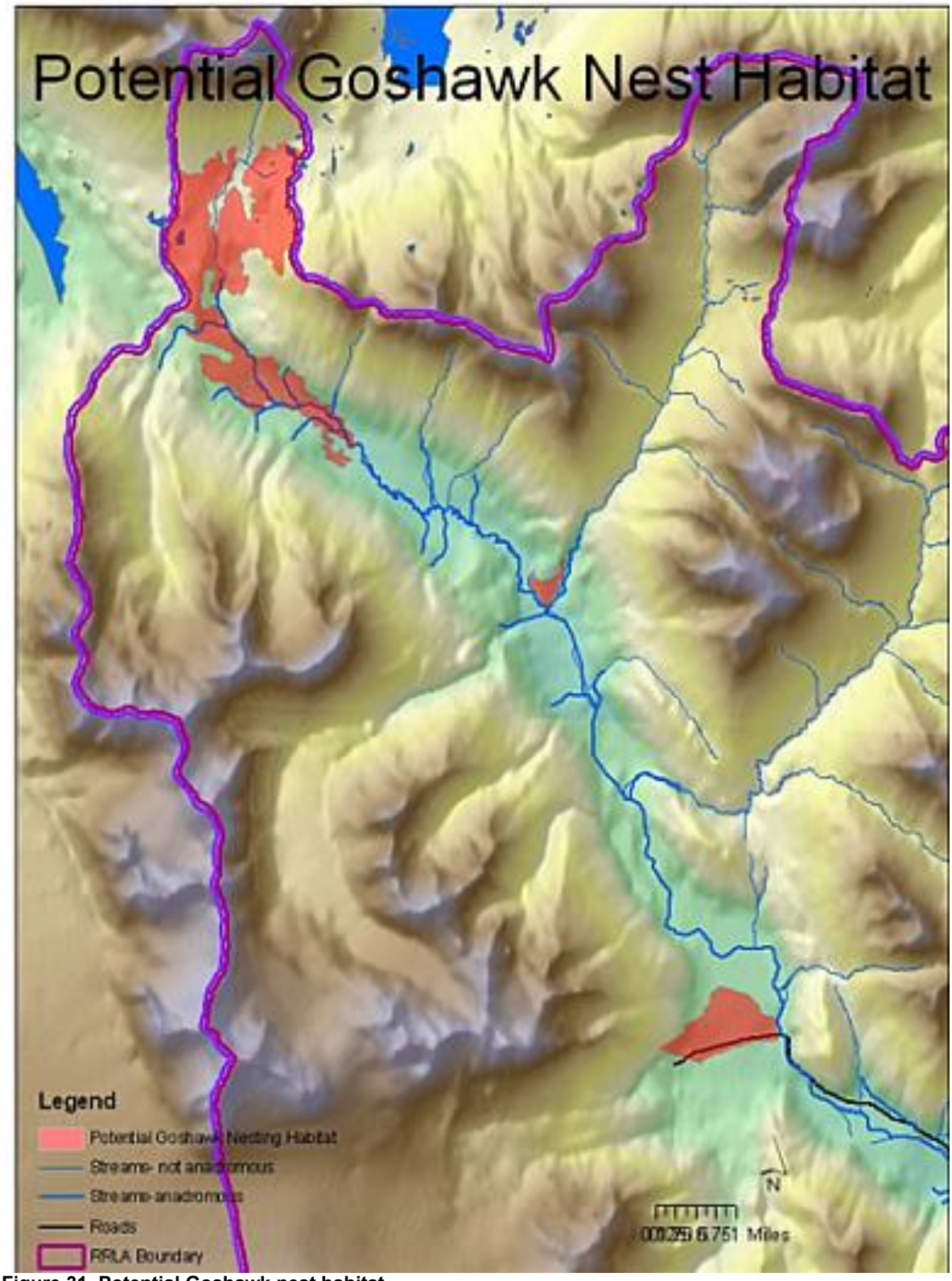

Figure 31. Potential Goshawk nest habitat

Marbled Murrelet

Marbled murrelets are medium sized seabirds that inhabit near-shore coastal waters, inland freshwater lakes, and nest in inland areas of old-growth conifer forest or on the ground (Carter and Sealy, 1986; Marshall, 1988). Except for the fall period when they are molting, flightless, and stay on the ocean, murrelets are known to fly to tree stands.

Marbled murrelet surveys have not been conducted in the watershed. Murrelets are known to use Resurrection Bay, and may use mature or old growth conifers in the watershed for nesting. Many of the large spruce have been affected by the spruce bark beetle. The majority of the watershed is within 30 miles of the coast, a distance which murrelets are known to travel inland for nesting. Areas of mature conifer forest are displayed in Figure 32. These areas may contain some potential nest habitat.

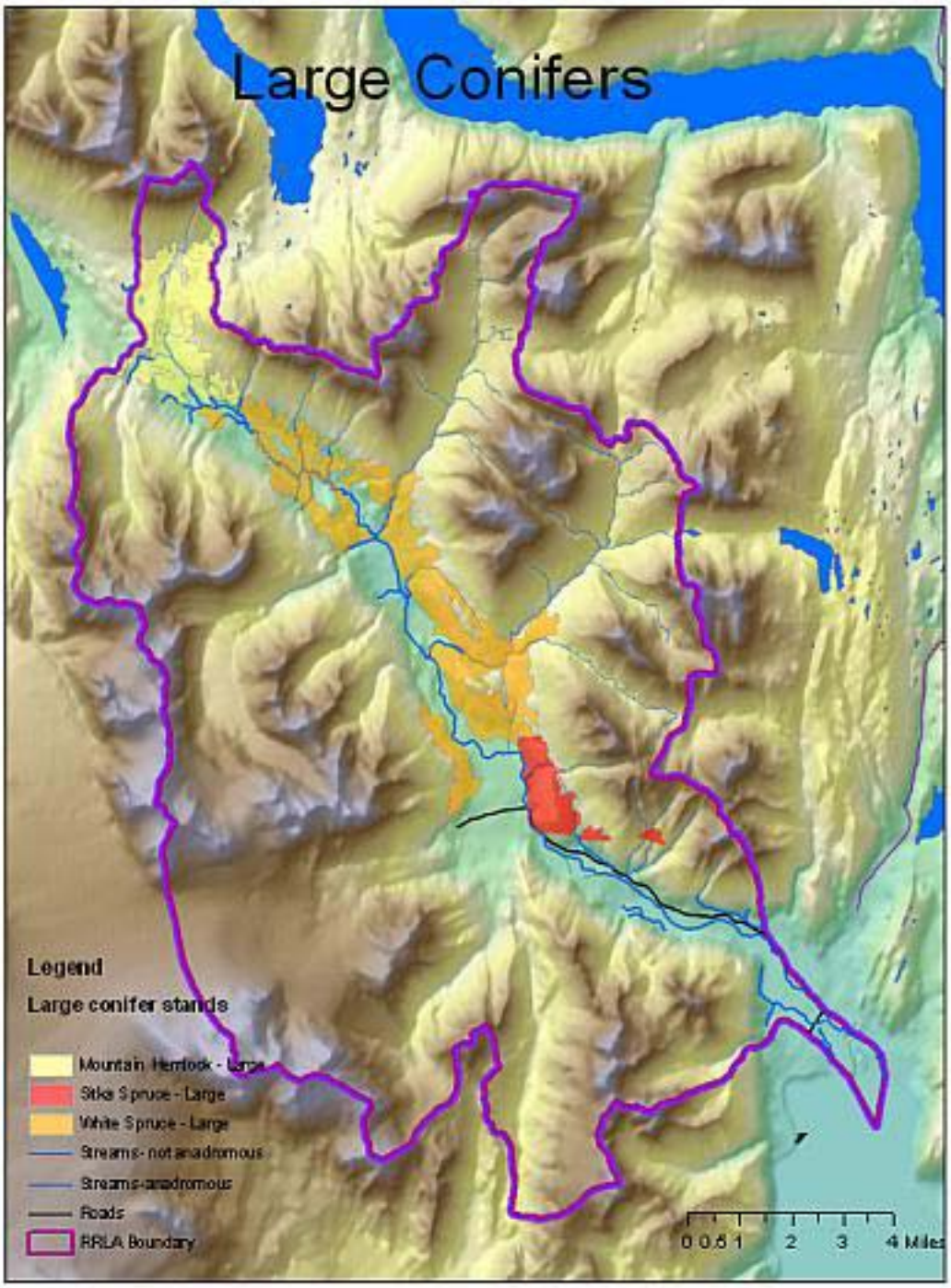

Figure 32. Large conifers

Townsend's Warbler and other Migratory Birds

Townsend's warblers are associated with older, mature spruce and hemlock forests and are not found as often in young coniferous or hardwood forests. Results from surveys on the Seward Ranger District indicate that they have declined in numbers between 1994 and 2000 (Prosser, 2002).

The bird survey route along the Resurrection River Trail has been conducted from 2003 -2005 (See Table 16). Townsend's warblers were identified during all surveys. Townsend's warbler habitat likely occurs throughout forested sections of this watershed, in mature hemlock and spruce-hemlock forests. Mature conifer forests and potential habitat for Townsend's warblers are displayed in Figure 32. Other species noted during these surveys are displayed in Table 16.

Table 16. Bird species noted during neo-tropical bird surveys along the Resurrection River Trail

- Bald Eagle
- Common Snipe
- Olive sided Flycatcher
- Alder Flycatcher
- Boreal Chickadee
- Golden-crown Kinglet
- Ruby-crowned Kinglet
- Swainson's Thrush
- Hermit Thrush
- American Robin
- Varied Thrush
- Or crowned Warbler
- Yellow Warbler
- Yellow-Rumped Warbler
- Wilsons Warbler
- Fox Sparrow
- Song Sparrow
- White-crowned Sparrow
- Golden-crowned Sparrow
- Slate-colored Junco
- Pine Grosbeak
- WH-winged Crossbill
- Pine Siskin

Several State of Alaska Species of Special Concern and Alaska Audubon Society watch list species are present in the Exit Glacier study area, including Townsend's Warbler, gray-cheeked thrush, and golden eagle. Townsend's warblers have been sighted in the study area during the breeding season (NPS 2002) and conifer habitat suitable for nesting is available. Decreasing populations in Alaska for this species are thought to be due to habitat loss in neo-tropical wintering grounds. Gray-cheeked thrushes have rarely been reported in the study area during the breeding season (NPS 2002) and suitable woodland nesting habitat is available. Decreasing population numbers for this species in Alaska are thought to be due to habitat loss in neo-tropical wintering grounds. Golden eagles are observed infrequently in the study area, primarily in the early spring. No known golden eagle nesting sites have been identified in Kenai Fjords National Park. Populations of golden eagle have been observed to be in decline in some areas; however, populations in Alaska appear to be stable.

There are 218 species of birds that occur or are expected to occur within Kenai Fjords National Park (AKNHP 2000). Of these, 143 species are expected to occur within the Exit Glacier study area, although a smaller number likely nest there due to limited available nesting habitat. Sixty-two species have been identified in the study area to date (NPS 2002). A survey of the occurrence and distribution of bird species in the Exit Glacier study area was conducted in 2000 and 2001 (Wright 2001).

A seabird colony also occurs at the wetland adjacent to the Seward Airport. This is an important habitat area for a wide variety of birds, and local birders and visitors often visit this area to view wildlife. A species list is noted in appendix B.

Trumpeter Swans

Trumpeter Swans are known to nest along Resurrection River near Placer and Moose Creek, and at a pond off Nash Road in Seward (see Figure 33). They have also been located near Exit Glacier (although they did not appear to be nesting). These are the only known nest locations on the Seward District of the USFS, although swans have been noted in other locations.

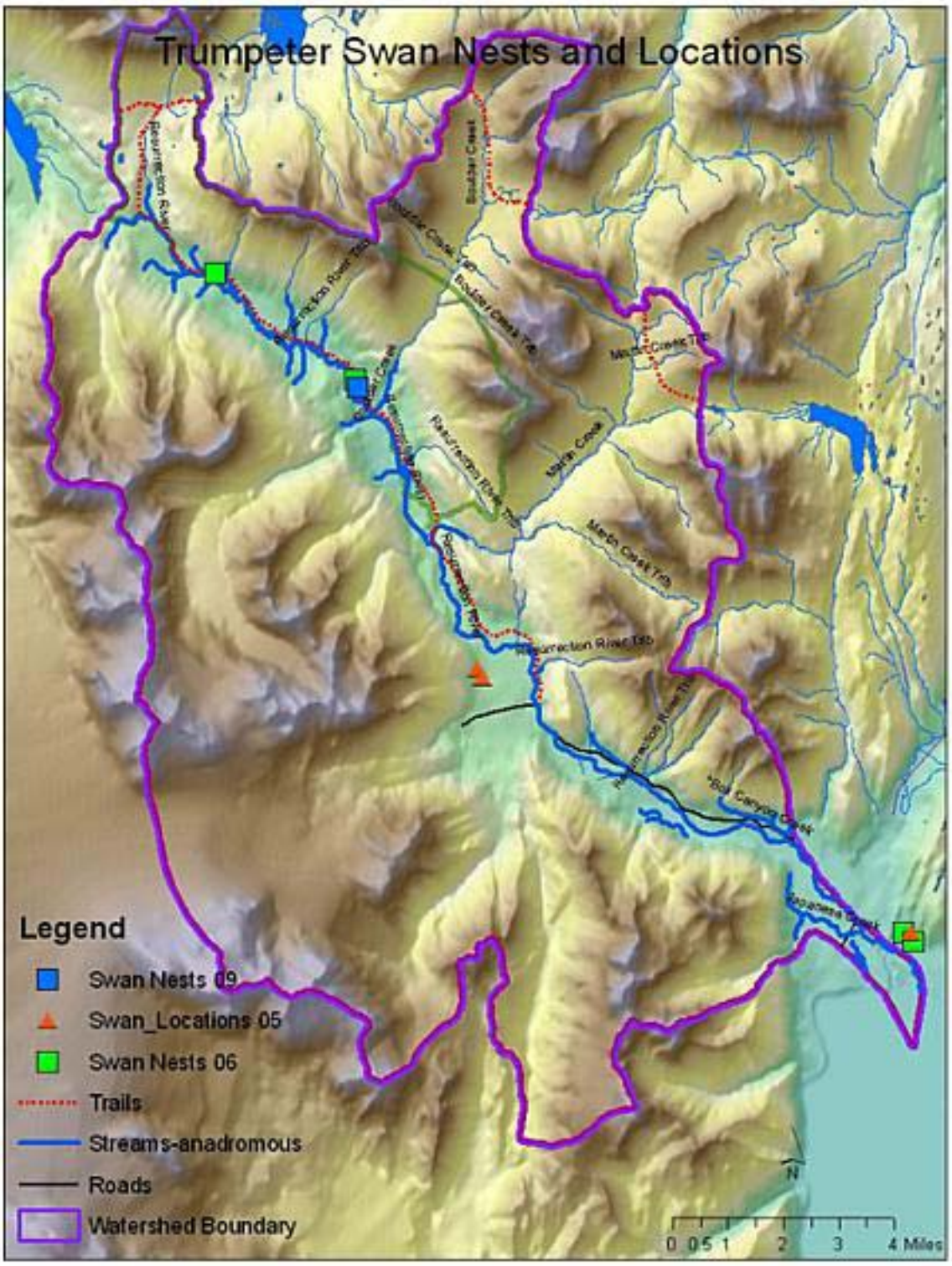

Figure 33. Trumpeter swan nests and locations

River Otter

River otters are associated with coastal and fresh water environments and the immediately adjacent (within 100 to 500 feet) upland habitats (Toweill and Tabor, 1982; USDA Forest Service, 2002b). Beach characteristics affect the availability of food and cover, and adjacent upland vegetation provides cover (USDA Forest Service, 2002b). Otters travel several miles overland between bodies of water and develop well-defined trails that are used year after year (USDA Forest Service, 2002b). River otters breed in late winter or early spring. Young are born from November to May with a peak in March and April (Toweill and Tabor, 1982). The family unit usually travels over an area of only a few square miles (USDA Forest Service, 2002b).

Data on river otter populations in the watershed are lacking (personal communication with Thomas Mcdonough, Alaska Department of Fish and Game, 2010). Potential habitat exists in Resurrection River and its tributaries. River otters may also use areas near the mouth of Resurrection River at Resurrection Bay. The Park Service notes that otter inhabit the river and creeks of the Exit Glacier area, but it is unknown if they den there.

Wolverine

The wolverine is a scavenger and opportunistic forager with a low biotic potential and large home range requirement. Similar to the brown bear, it is sensitive to human activities and development. Recreational uses and hunting may be population-limiting factors.

Little is known about wolverine populations and their use of the watershed. Wolverines travel over a wide range of habitats in search of food such as big game carrion (moose and goats) that occur within the watershed. Aerial track surveys conducted by ADFG in 2002 noted tracks adjacent to the watershed boundary near Upper Russian Lake. More recent surveys in 2009 did not cover the watershed. Occasionally a local or visitor will report seeing a wolverine near Exit Glacier on the ice field. Park service personnel noted wolverine use along Resurrection River. Potential foraging habitat exists throughout the watershed in areas used by moose, caribou, sheep and goats. Wolverine track observations suggest that they travel through the area searching for carrion and do not den in the area (Martin 2002).

Lynx

Lynx use a variety of habitats, including spruce and hardwood forests, in early successional communities. They require a mosaic of conditions, including early successional forests for hunting and mature forests for denning (Koehler and Brittell, 1990). Lynx habitat in Alaska occurs where fires or other factors create and maintain a mixture of vegetation types with an abundance of early successional growth (Berrie, 1973; Berrie et al., 1994). In Alaska, lynx tend to use elevations ranging from 1,000 to 3,500 feet and seldom use unforested alpine slopes (Berrie, 1973). Mating occurs in March and early April, and kittens are born 63 days later under a natural shelter such as a wind-fallen spruce or rock ledge (Berrie et al., 1994). Cyclic changes in snowshoe hare and other small mammal populations (Poole, 1994) influence the production and survival of lynx kittens dramatically. The populations of lynx on the Chugach National Forest are thought to be stable and within the range of historic viability (USDA Forest Service, 2002b). Lynx probably occur throughout forested sections of the watershed, but no data are available.

The Park Service reports that Lynx are extremely rare in the Exit Glacier area. Only three track observations have been recorded in the wildlife observation database between 1980 and 2002 (NPS 2002). An intensive track and baited photo station survey targeting mid-sized carnivores, including lynx, was initiated in the study area in 2001. To date, this survey documented one lynx observation from a set of tracks found in October 2001 (Martin 2002).

Gray Wolf

Wolves are habitat generalists. During winter, wolves are found at lower elevations in forested or woodland areas (Stephenson, 1994). Wolves are highly social animals and usually live in packs that include parents and pups of the year. Pack size usually ranges from two to 12 animals. In Alaska, the territory of a pack often includes from 300 to 1,000 square miles of habitat, with the average being about 600 square miles (Stephenson, 1994). Wolves normally breed in February and March, and pups are born in May or early June (Stephenson, 1994). One pack of wolves was known in the past to use the watershed (personal communication Ted Spraker, ADFG, 2001).

The Park Service notes that wolves are rarely observed in the Exit Glacier area, although tracks are commonly observed in winter snow. A total of nine wolf observations are recorded in the park's wildlife observation database (NPS 2002). Most recorded observations have been of one or two individuals. Given the low frequency of sightings and the small group sizes typically observed, it is unlikely that wolves den in or near the study area.

Sitka Black-Tailed Deer

Locals sometimes report seeing deer, and some say a healthy population lives behind the prison. Alaska Department of Fish and Game reports no documented reports of deer on the Kenai Peninsula (personal communication with Thomas McDonough, 2010). It is unknown if they inhabit the watershed.

Other Species of Interest

Dall Sheep

Dall sheep winter range only occurs within the watershed on about 565 acres on Cooper Mountain (See Figure 27). Sheep numbers in the Cooper Mountain area have generally been stable for the last several decades.

Barren Ground Caribou

There are no caribou herds in the Resurrection River area. The Killey River herd roams further to the west. There have been a handful of reports of the odd caribou or two seen around Exit Glacier area but these can be explained by dispersing individuals from the established Killey or Fox River herds (personal communication with Thomas Mcdonough, Alaska Department of Fish and Game, 2010). USFWS noted that there have been some caribou reported in the mountains adjacent to Exit Glacier (personal communication with John Morton, USFWS refuge biologist 2009). In 2010, a small group of what appeared to be pregnant caribou cows were noted near Exit Glacier in June (personal communication with Heather Mist Abad and Katy Salo, 2010).

Black Bear

Black bears are common in the Exit Glacier area. In early May bears are often observed above tree line on the north side of the Exit Glacier valley foraging on emerging vegetation. Black bears occur throughout the watershed.

Coyotes

Coyotes are more frequently encountered than wolves in the Exit Glacier area with numerous observations recorded in the park's wildlife observation database (NPS 2002). No den sights have been identified in the study area, though an observation made in 1998 of a family group near the Exit Glacier Ranger Station (NPS 2002) suggests that coyotes may den in the area. No data is available on coyotes on National Forest System lands.

Marten, Ermine, and Mink

These species are all present in the Exit Glacier area and likely throughout the watershed. Marten and ermine are common in all habitats and likely den in the area (Martin 2002). Mink inhabit the river and creeks of the study area. It is unknown if mink den in the study area.

Amphibians

Wood frog (*Rana sylvatica*) and boreal toad (*Bufo boreas*) are both reported as occurring on the Kenai Peninsula (Hodge 1976). An intensive survey for amphibians was conducted in the Exit Glacier area in 2001 and 2002 (Wright 2002). This survey resulted in no documented observations; however, there have been observations recorded in the wildlife observation database for wood frogs.

Heritage Resources

Less than 0.1 percent of the landscape assessment area has been surveyed for the presence or absence of cultural resources. Nine historic cultural sites have been identified and inventoried in the course of these surveys. Summary data about these sites are provided in Table 17; summary information concerning National Register eligibility for these sites is provided in Table 18. These sites have been reported to the Alaska State Historic Preservation Officer (SHPO), and they have been assigned both Alaska Heritage Resource Survey (AHRS) numbers. A summary of data concerning cultural sites identified within the assessment area is provided in Table 19. Since more than 99 percent of the landscape assessment area remains unsurveyed for cultural resources, the potential exists for further sites.

Table 17. Cultural Site Types in the Landscape Assessment Area

Site Type	Number of Sites
Historic Sites	9
Prehistoric Sites	0
Multicomponent Sites	0

Table 18. National Register Eligibility of Cultural Sites in the Landscape Assessment Area

Type of National Register Determination	Number of Sites
Cultural Sites Listed on the NRHP	0
Cultural Sites Determined Eligible for the NRHP	0
Cultural Sites Determined Ineligible for the NRHP	0
Cultural Sites Not Evaluated for NRHP Eligibility	9

NRHP: National Register of Historic Places

Table 19. Summary of Known Cultural Sites in the Assessment Area

Site Number	NRHP Status	Site Type
SEW-00028	undetermined	Historic
SEW-00148	undetermined	Historic
SEW-01038	undetermined	Historic
SEW-00835	undetermined	Historic
SEW-00241	undetermined	Historic
SEW-00422	undetermined	Historic
SEW-00420	undetermined	Historic
SEW-00419	undetermined	Historic
SEW-00418	undetermined	Historic

Kenai Mountains-Turnagain Arm National Heritage Area

On March 30, 2009, the Omnibus Public Lands Management Act of 2009 was signed, designating Alaska's first national heritage area, known as the Kenai Mountains-Turnagain Arm National Heritage Area, which focuses on the theme of transportation for mining and settlement. The Resurrection River drainage falls within the boundaries of this NHA, and the Forest Service anticipates working closely with the Kenai Mountains-Turnagain Arm Heritage Corridor Communities Association (KTCA) and National Park Service to interpret the historic resources in the area.

Recreation

There currently are a diverse array of recreational settings and opportunities on National Forest Lands in the watershed. The existing road and trail provide a fundamental framework to enhance these opportunities and maintain a variety of recreational settings and experiences. Because of the land ownership patterns in the watershed, collaboration among the managing agencies will be required to provide quality outdoor recreation opportunities and experiences.

The watershed includes approximately 43,437 acres of National Forest System lands. Approximately 26 percent of the Resurrection River Watershed area is in the backcountry management area as mapped in the Forest Plaor in management areas where recreation use is emphasized. The Backcountry management area emphasizes a variety of recreational opportunities in a remote setting.

On NPS lands, management of recreation is outlined in the Exit Glacier Area Plan and General Management Plan. The plan guides management of the area based on social and resource desired future conditions identified in each management zone. Resource and social indicators and standards are being developed to manage for desired future conditions. Documenting the number of people that visit the Exit Glacier Area and where they go is a current data gap. Visitor use is likely higher on NPS lands in the Exit Glacier Management Area than on the Chugach National Forest lands in the watershed.

Exit Glacier Special Management Area (State of Alaska)

Approximately 1,030 acres of State lands south of the National Forest boundary have been designated as Special Use Land under Alaska State Statute 11 AAC 96.010(b). Special Use Lands are designations place on land identified as having special resource values needing protection. The result of this designation may be to prohibit certain activities, or to require a permit for certain activities that would otherwise be considered "generally allowed" in order to protect those special resource values. The state-owned uplands along Exit Glacier Road are designed as Special Use Land because of their public recreation and tourism values. Camping is limited to eight days on these Special Use Lands, and sites that attract recurring problems such as long-term camps, abandoned trash and garbage, or sanitation problems may be closed.

Recreation

In comparison with other areas on the Seward Ranger District, recreation use is moderately high in the lower stretches of the assessment area primarily along the Exit Glacier Road. This is due to the close proximity of Seward. Terrain is also a factor in limiting use. In the upper watershed, use is moderately low. Recreation use is concentrated along established routes (the roadway, trail, and waterways) during both the summer and winter use seasons. These routes lie in valley bottoms, river corridors, and the upper alpine headwaters of Boulder Creek and Martin Creek. The existing recreation facilities in the Resurrection Watershed are presented in Table 20.

Figure 34. Resurrection River Trailhead

Table 20. Recreation facilities & trails located in the Resurrection River Watershed

Recreation Trails	Length/Location
Resurrection River Trail	16.2 miles
Resurrection River Cabin	N60 15’24”, W149 39’42”
Resurrection River Trailhead	N60 11.7’ 0”, W149 35.2’ 0”
Exit Glacier Overlook	N60 11.5’ 0”, W149 35.2’ 0”
Harding Ice Field Trail	7.4 miles

Trails

Forest Service Lands

There is one Forest Service System Trail in the Resurrection River Watershed. Table 21 contains recreation use data for this trail.

Table 21. Trail register count totals

Year	Groups	People	Biking	Hiking	Horse	Fishing/ Hunting	Skiing	Snow Machining	Over-night
2008	328	745	10	302	4	12	0	0	11
2007	343	784	5	331	0	7	0	0	?
2006	309	690	6	516	0	9	0	0	?

Recreation staff estimates that on an average about 33 percent of the visitors using trails on the Seward Ranger District actually register. Typically, horseback riders, bicyclists and snowmachiners do not register

at Forest Service trailheads. However, it can be assumed that the same number and types of users register across the district. Therefore, use numbers should be adjusted accordingly when estimating actual use of a trail.

As indicated in the table approximately 1,000 visitors travel into the upper watershed. The use data for this trailhead supports the assertion that recreation use is moderately low in the upper watershed. High use areas on the Seward District have over 1,500 users registering (4,550 visitors) annually at trailheads. Additionally, use levels have not increased over this 3-year period. There is no data on how many of these visitors are day users or overnight travelers. There is also no user data for the trailhead or out-wash plain as there have been a number of RVs and tents overnight sightings in these areas.

Trail Descriptions

Resurrection River Trail: - The Resurrection River Trail is a 16.2 mile trail beginning at mile post 7 of the Exit Glacier Road and ending at mile 16.1 of the Russian Lakes Trail. It is managed as a Class III trail (developed/improved) from the Trailhead to Martin Creek. From Martin Creek to the junction with Russian Lakes Trail it is managed as a Class II trail (simple/minor development). It is listed as a difficult trail in the Recreation Opportunity Guide with no bridges at the major stream crossings. It is not recommended for bicycle, horse or winter use. The entire trail passes through dense forest with a few vistas in the upper stretches. Berry picking and hunting are the primary activities that the trail provides access for. There are six identified campsites along the trail. The trail is part of a long distance trail system, comprised of Resurrection River Trail, Russian Lakes Trail and Resurrection Pass Trail, between Seward and Hope approximately 74 miles.

Goat Hunting/User Developed Trails: There are three known user developed trails in the management area. These are little known routes used primarily by a few locals. The first one is a goat hunting trail from Box Canyon Creek up into Resurrection Peaks. Another goat hunting trail starts up No-Name Creek and traverses into an area called Sugar Loaf. A miner's access trail leads up the north side of the drainage at 0.8 mile bridge on the Resurrection River Trail into the upper Martin Creek drainage. These trails are primarily used by hunters but a few mountain runners and adventurers use them.

NPS Trails

The Harding Ice Field Trail is a 7.4 mile trail within Kenai Fjords National Park. The trail takes off from the Exit Glacier Management Area and ends at the Harding Ice Field. There are also several short trails on the valley floor near the visitor center.

In 2009, from May-September, 9,795 hikers signed in to the register. The total number of hikers that signed in multiplied by the correction (1.47619) factor equaled 14,459 (Kreiedeman 2009, unpublished NPS report). From 2006 through 2009 there was an upward trend in hiker numbers, but it has leveled off in 2008-2009.

The following links provide detailed information about trails, recreation use and management of National Park Service lands near Exit Glacier within the watershed:

http://www.nps.gov/kefj/parkmgmt/exit-glacier-area-plan.htm

http://parkplanning.nps.gov/document.cfm?parkID=14&projectID=13653&documentID=14425

Public Use Cabin

Figure 35. Resurrection River cabin

Public Use Cabins - The Resurrection River Watershed contains one Forest Service recreation public use cabin. This cabin was taken off the reservation system in 2002 after heavy fall flooding in the Martin Creek drainage took out the 100 foot Martin Creek Bridge. Fording Martin Creek can be dangerous at times so the decision to take it off the system is for safety reasons. This cabin was one of the least used cabins on the district. During the 2001 season the cabin was used by 87 visitors. Its occupancy rate was comparable to the Aspen Flats Cabin. The current occupancy for Aspen Flats is approximately 69 visitors a year. Some use still continues by observations in the cabin log book but numbers are not recorded. Winter access has always been difficult with very limited use. There is also a cabin at Exit Glacier developed area on NPS lands that is available in the winter.

Forest Service Recreation Sites

Exit Glacier Overlook - This overlook is located at approximately mile 6.25 of the Exit Glacier Road. It overlooks Resurrection River west onto the Glacier. There are 17 vehicle parking spots. Maximum occupancy is 70 persons at one time. It is a popular viewing point for Exit Glacier.

Dynamite Road – A gated access that goes into an old quarry site located at approximately Mile 5.5 of the Exit Glacier Road. Some dispersed camping and target shooting occurs at this site.

Special Use Authorizations

Outfitter and Guide Commercial Use – There are approximately 5 outfitter and guide permits on National Forest lands. These guided activities consist of day hikes up Resurrection River Trail, raft trips down Resurrection River, and photo stops at the Exit Glacier Overlook. Exit Glacier Guides lead trips on NPS lands at Exit Glacier throughout the summer.

Reference Conditions

This section documents the knowledge of past conditions in the Resurrection River Watershed. In order to understand the condition and changes that have taken place, it is important to establish a frame of reference. For this analysis, the time frame for reference conditions varies based on times of important changes for particular resources. For some resource areas, little is known about changes over time, and proxy indicators are sought to help simulate what are thought to be reference conditions. In other cases, there are no good proxies for past conditions, and reference conditions may be based on knowledge of reference conditions of other watersheds, or knowledge of processes known to have taken place. Generally, reference conditions are those conditions that would be present if the watershed were operating without significant human influence. It is also important to note that many of the changes in the watershed since reference conditions are the result of natural geomorphic change.

Lands

The lands within the analysis area have historically been in federal ownership. These lands were originally held by the U.S. Government before Alaska statehood. After statehood and pursuant to ANILCA and ANSCA, the State of Alaska and several Native Corporations were granted the ability to "select" lands in federal ownership and retain those lands into private or State ownership.

Geology Minerals and Soil

Geology and Minerals

Reference conditions are not applicable to geology.

Soils

While landslides are a significant feature and hazard on the Forest and the Kenai Peninsula, no natural or management caused slope failures are mapped in the land system inventory coverage that exist for this watershed.

In addition to landslides, glaciers are the most significant landscape feature on the Forest, the Peninsula, and the Resurrection River Assessment Area. About 2,342 acres of glacier remain and are mapped (1980) within the Forest Service portion of the watershed, the only portion for which there is landtype level data. However, in the rest of the watershed, in addition to the Forest glaciers, the Harding Icefield can claim to cover over 300 square miles (483 km²) in its entirety (although, if one were to count its glaciers which descend from the icefield in all directions, the icefield measures in at over 1,100 square miles (1,771 km²) Wikipedia [1] The icefield spawns about 40 glaciers of various types. Some of the more notable glaciers include the Tustumena Glacier, Exit Glacier, and McCarty Glacier. The Exit Glacier, however, is the most accessible, being reached by a spur road off of the Seward Highway.

The icefield is also one of four remaining icefields in the U.S., and is the largest icefield contained entirely within the United States.[2]. The icefield itself receives over 400 inches of snow each year[3]. Differences in glacial area between Table 22 and Land System Inventory landtypes are likely due to the age of the mapping event. The Chugach Kenai Soil Resource Inventory (Arlene Davis, et. al.) is 1980 and Table 22 (NHD) is date unknown.

Table 22. Glacial area by watershed and ownership

Resurrection Watershed	Classification	Administration	Acres
Inside	Glaciers	AK Dept Natural Resources	771
		Kenai Fjords National Park	18,664
		Fish & Wldf Service	1,883
		Chugach National Forest	1,947
	Harding Icefield	Kenai Fjords National Park	2,594
Outside		Unclassified	407,625

While landslides are inconsequential in this landscape, the overall weathering rate and glacial recession are the most significant effect on the geomorphic surface and soil development in the assessment area. There are several glaciers within the assessment area that have/are receding.

As glaciers recede, the area of land where soil is beginning to develop is increasing. Recently exposed glacial surfaces may have a head-start on soil development compared to some other recent surfaces, for example, volcanic flows, depending on the glacial history and parent material. Even though the surface is ice-free in these areas, fundamental soil ecosystem processes are in a rudimentary stage if the geomorphic surface is less than about ten years old. Over the next decade to about 150 years, identifiable soil processes are initiated and process rates increase to measurable levels. These processes include: changing of the below-ground temperature regime, chemical weathering, and precipitation of soil minerals, colonization by bryophytes and early successional vascular plants, increasing chemical complexity, colonization and increasing complexity of soil wildlife and floral communities, and accumulation and transformation of soil organic carbon, among others.

After the basic soil system components are established, nitrogen, carbon and other cycling reach a stage where they are functionally stable. Higher plant communities including trees and shrubs establish and develop, further increasing organic matter accumulation. By this time, (after approximately 10 to 150 years depending on initial conditions), soil changes are fairly dramatic. Soil bulk density has decreased by 60 percent or more, pH has decreased from near neutral or higher to about 6 or lower as the result of weathering, and pedogenic horizonization has progressed to the degree that the soil classification will change from its original “entisol” condition, and after an additional similar time period, the soil changes would likely cause classification to change again. Along with these changes, soil characteristics, behavior, and responses to disturbance also change. For a complete review of soil development and surface age following de-glaciation, see Crocker and Major (1952); Tisdale and Fosberg (1966); and Yoshitake, et al (2006). Since the mid-1950’s, the average glacial recession of 67 glaciers in Alaska, including some on the Kenai Peninsula has been 1.8 m yr-1 (Arendt, et al, 2002). There can be some ponding of melt water below the glacial front for example, the lake below Trail Glacier, but there is generally rock, rock debris, and rock flour exposed. The Arendt recession rate equates to an average of about ninety meters of newly exposed surface for each glacier in the Peninsula, including the assessment area, ranging in age from the present to fifty years old. See Fiords N.P. April 20, 2010 meeting notes for end-moraine ages and locations since about 1815.

Natural soil erosion rates vary largely by soil type, slope, mulch or litter cover, and climate. Current conditions for natural landslides are low as discussed earlier. Typically, baseline erosion is within the range of about 0.1 to 0.001 tons acre-1 year-1. Accelerated erosion from timber harvest-vegetation treatment, construction, severe wild fire, livestock grazing, or intensive agriculture can be over 800 tons per year. Within the Resurrection River Landscape Assessment area watershed, undisturbed, natural conditions produce only a baseline soil erosion rate.

Current development and ongoing management activities that have or could continue to disturb the soil cover and accelerate erosion affect less than about 700 acres in the assessment area, and include roads, trails, and recreational developments. Roads and trails take up about 8.2 and 28.2 acres, respectively. Exit glacier overlook parking lot, and a public use cabin about an acre; an old quarry site and seven inactive mining claims, about 642 acres. The current soil surface status of these acres is not known.

Apparently, vegetation is not significantly different from 100-150 years ago or longer (Marcus Chin, ID Team notes of 4/20/2010). There has been no organized timber removal or management. There is no evidence of large or severe fires during that time period either (Todd Camm, ID Team notes of 4-20-2010), so the soil has likely been very stable, allowing organic acids to dissolve organic matter along with Al and Fe from the surface layer (E horizon) to an illuviated subsurface layer (Bh/s horizon). This process is called podzolization (see , the comprehensive name for the process of mobilization and precipitation of dissolved organic matter, together with aluminum Al and iron Fe leaching from the A and E horizons to the B horizons. Through this process, the overlying eluvial horizons are getting bleached. The complexes which consist of cemented sesquioxides and organic compounds. The process of podzolization occurs usually under low pH. The corresponding soil type is called Podzol, but the modern synonymy for Podzol in China and the United States is called Spodosols, in Brazil it's called Espodossolos and in Australia Pedosols. The Podzols are typical soils for humid boreal and humid temperate zones. Podzols cover about 485 million ha worldwide and are usually found under coniferous forest or under heather. Podzols are able to occur on almost any rock, and form on quartz-rich sands and sandstones, or on sedimentary debris from magmatic rocks, provided that there is relatively high precipitation.

Hydrology

Reference conditions for water resources are defined as the conditions that existed prior to human development within the watershed. At this time, no roads or highways existed in the watershed, and the majority of streams were undisturbed by human activities. Information about reference conditions must be inferred, as photography and other information are not available.

Geomorphologic Trends

Episodes of extensive glaciation and recession have occurred in south-central Alaska in the past 2 million years, with the last peak of glaciation occurring in the late Pleistocene (20,000 to 25,000 years ago), when glaciers filled the Resurrection River valley. Rapid melting occurred in the Holocene, beginning about 12,000 years ago, accompanied by numerous episodes of small advances and retreats. The last glacial maxima occurred during the Little Ice Age (approximately 1350 to 1870 AD). At that time, Exit Glacier extended nearly to the Resurrection River, and other glaciers in the watershed were likely considerably larger than they are today. By the early 1900s, glaciers in the watershed began retreating fairly rapidly.

During the reference period, the landscape of the Resurrection River watershed was more dynamic than it is today. With increased glacial coverage, sediment loads were higher in the Resurrection River, leading to active glacial outwash channels with frequently migrating channels. With sizeable glaciers in most of the tributary watersheds, alluvial fans were likely very active because of high sediment loads. Streamflows may have been slightly higher during the reference period than they are today because of the higher percentage of the watershed covered by glaciers.

Human Impacts to Water Resources

River and stream channels in the Resurrection River watershed during the reference period functioned primarily under natural processes. Prior to human development in the Seward area, river and stream channels were unimpeded by roads, bridges, levees, or other artificial controls, and human impacts to

water resources were non-existent. Although there were no human impacts to water quality, the water in most streams was moderately to extremely turbid as a result of glaciers.

Impacts of Channel Changes and Flooding

During the reference period, the Seward area was minimally developed. Flooding was likely fairly frequent because of the typical weather conditions and the presence of glaciers in the watershed. Glacial outburst floods may have occurred in the system. However, channel changes and flooding in the area did not have a large effect on human developments or populations.

Climate

Prior to the early 1900s, it is likely that the climate was slightly cooler than it is today. The current trend of climate change that can be attributed to emissions of greenhouse gases was not occurring during reference conditions. However, the global climate was in a state of warming after the Little Ice Age.

Vegetation and Ecology

No specific historical reference data exists for this watershed, so reference conditions are not known with certainty. Areas that have not been altered by anthropogenic disturbances are considered to be in the same condition as pre-settlement. Several disturbance agents have caused the pattern that is now seen on the landscape. Historically, the most significant disturbance agents in this watershed would have been glaciers, landslides, avalanches, forest insects and diseases, floods, and possibly occasional wildfires.

Vegetative patterns in the late 1800s would probably have been very similar to current conditions, with a notable exception. As time has progressed, glaciers have receded and as they have receded they have been replaced by plant communities. As time progresses and forest succession continues, areas that were de-glaciated in the late 1800s could be fully mature spruce forests at present. Beyond glacial melting, other processes at work have probably not significantly changed the composition of the watershed. When Langille explored the Kenai Peninsula in the early 1900s, he saw many dead trees, which may have been bark beetle killed trees (Langille 1904). There are differing opinions on whether or not the current bark beetle epidemic exceeds historic levels.

Botany and Weeds

Non-native Plants

Prior to significant human settlement in the 1800s, there were likely no non-native plant species in the project area. Non-native plants become introduced in a variety of ways, mostly associated with human activities such as intentional planting in gardens or for revegetation purposes, and accidental introductions via seeds and plant materials transported via vehicles or livestock.

Sensitive and Rare Plants

There is no reference condition data for sensitive and rare plants. Historically, the *Papaver alboroseum* may have been more common as receding glaciers revealed potential habitat. However, as these sites continue to grow in with vegetation, habitat for the *P. alboroseum* may diminish.

Fire and Fuels

Prehistoric

The evidence for prehistoric fire events on the forest from radiocarbon dates on soil charcoal range from 4,500 years before present (ybp) to 570 ybp (Reiger 1995). Historical evidence supporting a climax forest is found in Langille 1924 and Holbrook 1924. Both concluded from old logs and decayed stumps of large size, that a prehistoric forest of greater proportions once existed, probably destroyed by fire before the Russian occupancy of the region. Although large historic fires were recorded on the Forest during the settlement period, we do not know how this compares with the number and size of fires during prehistoric fire history.

Settlement

Beginning in the late 19th century and continuing through the early 20th century, this period shows high fire frequencies on the Kenai Peninsula. Perhaps the earliest written occurrence of Russian occupancy on the Forest was in late 1793 (Pierce, 1980). Russian shipbuilders prospected in the Kenai Peninsula Mountains for iron ore. The iron ore was transported down along Resurrection to the bay.

The coming of the American gold seekers saw the first use of the forests, exploiting the forests to obtain lumber for sluice boxes (Langille, 1904). Many of the gold seekers were careless with fire, with the result that they burned not only a large part of the timber but their cabins and outfits as well (Holbrook 1924).

Commentaries from the foresters diaries early in this century, describe extensive fires on the Forest between 1913- 1915. The basic cause for these fires was attributed to railroad activity igniting 95 fires between 1932 and 1953 (Blanchet 1987). The drought conditions following the 1912 Katmai Volcano eruption also contributed to the fire behavior creating favorable weather for burning. Holbrook (1924) also reports “the region has been visited by numerous fires and most of the better grade of timber has been burned.” He mapped approximately 30,000 acres of burned area on the forest. These large disastrous fires included the Resurrection Creek watershed covering 10,000 acres including the Hope fires; namely Cripple Creek, Bear Creek and Sunrise fires (1904-1930) burning a total of at least 6,000 acres.

Post-settlement

Human impact on the forest has varied and early impacts have been masked by those which came later. Existing fire report data starting in 1933 show that there have been 12 documented responses to fire starts in the Resurrection River drainage and it is very safe to say that the total number of ignitions that may have taken place is higher as there is evidence that fire suppression activities have taken place without the knowledge of state and federal land agencies. For the time period and proximity to a community the size of Seward this number may seem to be extremely small considering the amount of use this drainage receives. Further research into why this number is so small has revealed that there was limited access to Exit Glacier and the upper reaches of the drainage as there was no road access until the late 1970s. Since the vast majority of ignitions on the Chugach are human caused this lack of access has limited the numbers of opportunities for human caused ignitions to take place in the drainage. Fire occurrence data has not shown this drainage to have experienced any large fire activity for at least several hundred years and the size of the standing spruce in the lower end of the drainage attest to this. All of the fire starts in the drainage are small fires under 0.1 acre in size, and all recorded fires have been human caused.

Aquatic Species and Habitats

Reference period is pre-development, pre-Seward Highway. The Chugach National Forest was established July 23, 1907. The Alaska Railroad was completed in September 1918 from Seward to Anchorage. The

Seward Highway was completed in 1951 for traffic from Seward to Anchorage. Kenai Fjords National Park was established with the signing of the Alaska National Interest Lands Conservation Act (ANILCA). Exit Glacier Road construction began in 1965 and by 1971 the gravel road had been completed from the Seward Highway to the east bank of the Resurrection River (Cook, 1998)

Canneries and salteries began to appear in Seward around 1912 but closed shortly after. In 1917 the first cannery opened in Seward and for the next forty years Seward had an operating cannery. Then in 1924 a hatchery was built at Grouse Lake that raised Chinook, sockeye and pink salmon. The hatchery was destroyed by fire in 1927 and was not rebuilt (Cook, 1998).

Resurrection River Trail construction began in the late 1970 and continued into the early 1980s. The construction of this trail opened this currently inaccessible area to more foot traffic into the back country. This trail was also connected to the Russian Lakes trail. Resurrection River had two larger bridge crossings on Martin Creek and Boulder Creek and both of these bridges were destroyed during typhoon events. The bridges have not been replaced and the trail above these areas has been designated as primitive.

Terrestrial Species and Habitats

Reference values are the baseline to determine change in the watershed and provide a basis for comparison. Reference values are the conditions that would be expected if the watershed did not have significant human influences. For this analysis, reference conditions generally refer to the prior to the settlement of Seward around 1903. In 1793 Russians were present in the Seward area building a ship named “The Phoenix” and Alaska natives were present. The Russians probably traveled in the watershed in search of iron and game for subsistence. The number of people inhabiting the watershed is unknown but expected to be small. There is evidence of native human use up the Resurrection River valley within the park service boundaries from the Exit Glacier area (personal communication with Kristina Kriedeman, NPS 2010). After Seward was founded, numerous photos show the residents with dead animals from hunting or trapping expeditions including moose, Dall sheep, mountain goat, bear, and numerous small mammals. The census in 1910 notes 438 people in Seward. It is likely there were never high numbers of people in the watershed until after the Seward Highway was built and paved.

Past populations of wildlife are unknown, except that moose were not here prior to about 1850 (personal communication with Tony Largaespada, district archaeologist, 2004). The presence of moose is likely due to extensive expansion of hardwoods from human caused fires at the turn of the century. It is likely that other species that use hardwoods such as lynx and birds have increased, and potentially species such as brown and black bear that prey on moose may have increased as well.

Hunting and trapping pressure by native people, the Russians, and early miners may have influenced populations locally in the past. Impacts to wildlife are unknown, but may have been heavy at times.

Travel routes and trails likely existed in the watershed in areas similar to what exists today, but with much more rustic conditions and less use than today.

Historic data on vegetation composition and structure is not available from the reference period. More of the watershed was likely covered in ice, as was most of the developed area of Kenai Fjords National Park near Exit Glacier. There was significant change in climate during the 1800s (Kreideman 2010). In other areas, and likely in this watershed, humans impacted vegetation by cutting trees to create homes and other structures, provide fuel, and started fires which reduced large trees and created more early seral hardwoods.

Threatened or Endangered Species

No threatened or endangered species are known to have occurred in the watershed during the reference period.

Sensitive Species

No sensitive species are known to have occurred in the watershed during the reference period.

Management Indicator Species

Moose

Very limited information is available to describe reference conditions for moose in the watershed. Evidence suggests that moose were not present on the Kenai Peninsula until 150 years ago (Largaespada, 2005).

Mountain Goat

No quantitative data exists to indicate what reference conditions were for mountain goats in this watershed. Increased hunting pressure after initial European contact may have reduced mountain goat populations; however, mountain goat habitat has probably remained relatively unchanged. Warming conditions however are likely increasing the extent of forested habitat up mountain slopes, which ultimately will decrease available alpine habitat for mountain goats over time.

Brown Bear

Data on reference conditions of brown bear is very limited to nonexistent. We assume that historic populations of brown bear were higher, and that European contact decreased brown bear populations through habitat loss, hunting and defense of life and property (DLPs), although potential increases in fisheries, moose populations could have increased bear numbers. The more recent increase in recreation in the watershed has resulted in some habitat encroachment and increased DLP mortalities.

Species of Special Interest

Wolverine

Little to no data exists on reference conditions for wolverine. As with all fur-bearers, populations may have decreased after European contact due to the increase in hunting and trapping, and habitat encroachment by humans.

Northern Goshawk

No quantitative information exists on reference conditions for goshawks. Undoubtedly, goshawks have been impacted by the spruce bark beetle infestation, reducing potential nesting habitat.

River Otter

No quantitative data exist for reference conditions. Reports from the 1920s indicate Peninsula-wide scarcities, more than likely a result of increased trapping pressure after European contact. It is unclear how recreation and increased human use may affect river otter populations.

Lynx

Quantitative data regarding reference conditions for lynx are nonexistent. Reports from the 1920s (Culver, 1923) indicate lynx were widespread on the Kenai Peninsula. As with all fur-bearers, populations probably decreased after European contact due to the increase in hunting and trapping.

Marbled Murrelet

Quantitative data regarding reference conditions for marbled murrelet are nonexistent. It is likely that because of the proximity to the coast, some nesting habitat may have been available in stands of large conifers.

Townsend's Warblers

Data on reference conditions are unavailable. Forest Service surveys from the late 1970s indicate that Townsend's warblers were the most abundant species in older forests and were not abundant in recently burned forests. European contact may have decreased Townsend's warbler populations if older forests were altered, but overall impacts on the population were probably minimal. Forest fires and the spruce bark beetle over the last 100 years have also reduced available habitat over time.

Gray Wolf

No data exists on reference conditions for gray wolf in this watershed. The wolf population more than likely suffered declines after the influx of European settlers, as hunting pressure of all fur bearers increased at this time. However, wolf populations may have increased with the increase in the moose population beginning 150 years ago.

Other Species of Interest

Dall sheep

No quantitative data exists to indicate what reference conditions were for Dall sheep in this watershed. Increased hunting pressure after initial European contact may have reduced populations; however, habitat has probably remained relatively unchanged. Warming conditions however are likely increasing the extent of forested habitat up mountain slopes, which ultimately will decrease available alpine habitat for sheep over time.

Barren Ground Caribou

No information exists on reference conditions. Some sources indicate that prior to the turn of the century caribou were an abundant ungulate species on the peninsula. It is unknown if caribou once existed in the watershed. Now they are rarely sighted. It is likely that caribou, if in the area, were hunted by native people for subsistence and at times this may have affected the population.

Black Bear

No information exists on reference conditions. The bear population more than likely suffered declines after the influx of European settlers, as hunting pressure of all fur bearers increased at this time.

Coyotes

No information exists on reference conditions. The bear population more than likely suffered declines after the influx of European settlers, as hunting pressure of all fur bearers increased at this time.

Marten, Ermine, and Mink

No information exists on reference conditions. The bear population more than likely suffered declines after the influx of European settlers, as hunting pressure of all fur bearers increased at this time.

Amphibians

No information exists on reference conditions. Climate change has potentially affected the populations or distributions, although they may never have been abundant.

Heritage Resources

Reference conditions for Heritage Resources are included within the Watershed Characterization section.

Recreation

The reference condition for recreational activities and development within the valley dates back to the development of the road and trail. As the road progressed up the valley during the late 1960s and early 1970s people expanded their recreational activities as access became easier. Prior to the road development there was little recreational use in the upper watershed.

Lands

The forest boundary that crosses the Exit Glacier Road at Mile 3 is the originally designed boundary set in 1907 when the Forest was created. Public lands to the south of the forest boundary at one time were managed by the BLM prior to being transferred to the State. Kenai Fjords National Park was established in 1980 with the signing of the Alaska National Interest Lands Conservation Act (ANILCA). Prior to 1980 these lands were managed by BLM.

The reference condition for this analysis area is prior to the start of construction on the Exit Glacier Road in 1965. Before 1965 locals utilized the area for mining, hunting, logging fishing, and activities associated with subsistence use but little to no recreational activities.

During the 1960s and 1970s, outdoor recreation expanded exponentially nationwide. South-central Alaska's population rose from 50,000 in 1950 to 110,000 is 1970, and from then to 300,000 in 1985. Alaska residents continually seek recreation activities in a natural setting, while expanding tourism continues to attract many more visitors to Alaska. The Forest Service expanded and improved campgrounds, trails, and trailheads on the Seward Ranger District during the 1960s and 1970s in response to the increased public demand. The 1964 earthquake underscored the critical need to diversify Seward's economy. Residents felt that Resurrection Glacier would be an excellent new sightseeing destination. The road was completed in 1980 with the construction of a pedestrian bridge over Resurrection River. This easier access was the turning point for recreational activities in the Resurrection River watershed.

During the last 30 years, human development in the area has greatly increased the number of people utilizing the Resurrection River Watershed.

Synthesis and Interpretation

This section summarizes and compares existing and reference conditions for the Resurrection River watershed and describes the trends and processes that are occurring through time. This synthesis is important for identifying the capability of the watershed to achieving management objectives presented in the following sections.

Lands

There is very little difference between the reference and current conditions. The lands within the analysis area were historically federally owned and remain federally owned. The only difference is that historically the analysis area was wholly owned and managed by the U.S. government; whereas, currently management is now divided between the USDI Park Service and the USDA Forest Service with the Resurrection River serving as the boundary. As Resurrection River is constantly changing, the boundary between the USDA Forest Service and the USDI Park Service lands is nebulous. Therefore, a precise boundary between these two landowners is not currently possible.

Geology Minerals and Soil

Geology and Minerals

This section is not applicable to Minerals and Geology.

Soils

Reference conditions compare favorably to the current conditions in regards to mass-wasting. Although the overall extent of natural slope failures is unknown, there are no known management caused failures. Non-glacial erosion processes other than mass-wasting are not known to be accelerated on FS lands within the analysis area.

Even though the area involved is relatively small, glacial recession is having the most effect on the geomorphic surface and on soil development on lands in the assessment area. This is expected to continue at an increasing rate in the future. Depending on how long formerly ice-covered ground has been exposed, after as little as 10 years to more than a century, soil changes will include lower bulk density, lower pH, changing soil chemistry, and other alterations due to chemical and biological weathering, precipitation of soil minerals and colonization by bryophytes and ruderal vascular species. Some of these recently exposed sites may eventually become prime colonization sites for weedy invasive species. If other disturbance, for example, erosion were to be introduced, then weed species will continue to occupy these sites and prevent or slow natives from establishing.

The same climate changes driving glacial recession may cause the fire incidence rate to increase, which would increase the background soil erosion rate on most soil types and land types. If fire incidence accelerates greatly, soils that are currently carbon-sinks could become carbon sources. As these glacial changes occur and alter soil exposure and weathering rate, soil chemical, physical, and biological properties will change at an increasing rate, resulting in positive feedback which will further drive soil weathering and development.

The quarry/gravel pit that is part of the managed acreage would naturally restore itself somewhat but would still be identifiable 50-100 years out. Even with maintenance, some trail erosion will be identifiable.

Hydrology

Geomorphologic Trends

From reference conditions to current conditions, the Resurrection River remains heavily influenced by glacial activity. Glaciers shaped the watershed and still result in high sediment production and dynamic shifting outwash channels and alluvial fans. The high relief narrow valleys have always been prone to

landslides, which can cause debris dam outburst floods. Water quality remains turbid in the Resurrection River and many of its tributaries as a result of glacial sources.

Human Impacts to Water Resources

Human developments have impacted stream channels by modifying flow patterns. Roads and bridges impact natural channel processes and limit channel migration. Particularly near Seward, levees constructed on alluvial fans prevent natural channel migration from occurring as it naturally would. Development near Seward has altered natural processes of channel function and sediment deposition from natural conditions, but human impacts to water resources are limited on National Forest system lands.

Impacts of Channel Changes and Flooding

The impacts to human developments from channel changes and flooding have been steadily increasing as the area has become developed over the past 100 years. Most of these impacts occur on non-National Forest system lands in the Seward area, where development has occurred on several alluvial fans and in the floodplain of the Resurrection River. The need to protect developments from floods has increased, but this becomes a more and more difficult task as more of these floodplain areas are developed. These issues are being addressed through improved mapping and regulation in floodplains, wetlands, and hazard zones. Impacts of channel changes and flooding on National Forest system lands in the watershed are limited to localized impacts to trails, trail bridges, and roads.

Climate

Changes in climate over the last century have had and will continue to have an effect on hydrologic processes in the Resurrection River watershed. The current trend in climate change will continue to bring gradual long term changes to hydrologic conditions as a result of changes in precipitation patterns, snowpack, glacial extent, and the condition of riparian vegetation. The magnitude of many of these impacts is unknown, and data are limited. The magnitude of this issue is increasing and will play a larger role in future management decisions.

Vegetation and Ecology

Understanding the changes between reference conditions and current conditions is difficult because reference condition data is not available for the specific area of this watershed. It may be assumed, however, that human causes of change would probably be restricted to human disturbances that are readily observed, as opposed to subtle human alterations such as fire exclusion.

The primary natural disturbance agent driving succession in this watershed appears to be the spruce bark beetle (*Dendroctonus rufipennis*). Areas of dead white spruce were noted, which is indicative of bark beetle infestation. Stands of mountain hemlock were interspersed with the stands of dead spruce, so it is probable that mountain hemlock was present in the understory of these stands. If hemlock was present in the understory, it has probably been released and these stands are now in the climax stage of succession. Within the hardwood stands, senescence and stem decay are the most significant natural disturbance agents.There are five different management areas on the Chugach National Forest portion of this watershed and understanding the prescriptions for these management areas (MAs) is the key to understanding if the system can be modified to meet plan objectives (see Introduction).

According to these prescriptions, the management areas that need to be looked at the most carefully to understand if objectives are being met for vegetation are the Brown Bear Core MA and the Fish, the Fish and Wildlife Conservation MA, and the Wildlife, & Recreation MA.

The ecological systems desired condition for the Backcountry MA is that "Ecological processes, largely unaffected by human activity, dominate Backcountry Management Areas" (USDA Forest Service 2002). If vegetation is left undisturbed by humans, management objectives for this area can and will be met. For the Minerals Management Area, objectives given for vegetation would only include ensuring that land affected by mining operations is effectively rehabilitated. The ability of the system to be rehabilitated from mining operations is dependent upon the type of mining operations carried out on this land, but it is likely that this objective could be met.

Brown Bear core objectives will be met by simply allowing forest succession to occur. The Brown Bear Core area in this watershed is a mixture of barren ground, alder, alpine vegetation, and areas of white spruce and mountain hemlock. The RLRMP describes the desired condition of ecological systems in the following way:

> A mix of late seral forests, unmodified landscapes and managed vegetation characterizes these areas. The varied habitat types provide foraging sites, security cover and travel corridors to meet the seasonal needs of brown bears…Generally, the vegetation will be managed to allow succession to late-seral conditions. Alterations to various age classes and structural conditions may occur throughout the area as needed to maintain habitat conditions for brown bear (USDA Forest Service 2002).

By simply allowing forest succession to occur, objectives for this management area are met. During analysis, it was noted, that early seral species were notably absent from this area.

The Fish, Wildlife, and Recreation Management Area "will contain a mix of vegetation mosaics of various types, age classes and structural stages" (USDA Forest Service 2002). Reliable vegetation only exists for a portion of this management area, so vegetation mosaic is not known.

The Fish and Wildlife Conservation Management Area contains barren snow and ice, so vegetation manipulation is not possible for the small portion of this management area that is located within the analysis area.

Botany and Weeds

Non-native Plants

The introduction and spread of invasive plant species is a growing concern in Alaska. Based on existing information, most areas of non-native plant occurrence are in areas of human-caused disturbance such as edges, visitor facilities, trailheads and trails. Non-native plants are rare within natural communities and undisturbed areas. Owing to the relative rarity of invasive plants in the area, land managers of the Chugach National Forest are in a unique position to prevent invasive plant problems before they occur. Prevention is generally much cheaper than control and identifying outbreaks early and responding to them quickly can reduce costs.

Land managers can follow the Chugach National Forest Invasive Plant Management Plan to assist in accomplishing invasive plant management goals. Under this plan, invader sites and new infestations of priority species would be inventoried and brought under early treatment strategies, including containment (prevention of offsite movement), control, and eradication as rapidly as possible. Monitoring and annual evaluation would be initiated. Established infestations would be inventoried and managed based on objectives and priorities.

Sensitive and Rare Plants

To date only the *Papaver alboroseum* has been found in or near the landscape area. This may be a data gap since most of the landscape area has never been surveyed. Additional information is needed to refine and validate the habitat diversity/bioenvironmental model. This would likely include systematic surveys to document the presence and distribution of sensitive plants throughout the watershed in order to protect existing populations and improve predictability of identifying potential habitats identified by the habitat diversity model.

Fire and Fuels

Little reference information is available for fire and fuels in the watershed. We do not know how things have changed over time other than the fact that there are no indicators that the natural life cycle of the vegetation here has been altered. At this time there is little data, research, or actual evidence (snags, charred woody materials) to utilize for study in the lower drainage to even allow us to give a reasonable estimate as to when, if ever, this drainage has experienced any form of large fire activity. It is obvious that the upper drainage has experienced stand replacement fire events as characterized by the beetle impacted stands of Spruce present located there. The timeline for such an event is on a scale measured in hundreds of years. Subsequent research in the drainage may give us an idea of when that happened.

Our predictions are that the following changes have occurred:

The current Spruce bark beetle infestation in the upper end of the watershed may result in an increased risk of natural or human-caused wildfire, with the possibility of associated degradation of air quality.

There is a very real likelihood that increased recreation use in the Resurrection River project area will increase the potential for an increased volume of ignitions to take place, thus increasing the potential and likelihood that large fires will occur. Though there is no real way to prove that this increase could or would happen, there is evidence present in existing fire records to support that the potential is there and will increase over time as vegetative conditions change and/or deteriorate. Fire records dating back to 1932 show 12 known initial attack fire suppression responses in the Resurrection River project area. There may have been many more fire starts or suppression responses during this time as there is no record of how many abandoned campfires, debris fires, discarded cigarettes, etc, burned themselves out without a response or were suppressed without being documented. In regards to the known number of responses all have been directly tied to human use and all have taken place within ¼ mile of existing roads and trails.

Spruce bark beetle infestation has led to an increased risk of fire and a short-term increase in large woody debris recruitment potential. The beetle infestation by itself has not affected recreation significantly, though it has raised the risk of wildfire in areas which provide recreation opportunities or access to recreation opportunities. The increased use of travel corridors by visiting forest users may have an increased risk of fire starts though the impacts of beetle infestation are not evident in the lower drainage. There is the chance that, if an unplanned ignition were to take place in the lower drainage (i.e. below the Resurrection River Trailhead) suppression resources would be overwhelmed and fire could move down the drainage towards Seward if pushed by some form of high wind event. The likelihood of this taking place is very small though still possible. The area in question is considered to be a Full Suppression response and any ignitions that take place will receive an immediate response fitting of the situation at hand. As for back country recreation taking place in the Resurrection River, there is supporting data that clearly shows some fires caused by humans but not to the extent of the main travel corridors. The risk is present within the dead spruce, heavy down fuel accumulation and grass micro sites. Most of the drainage above Resurrection River Trailhead is in the Limited Response Fire Management Zone and would receive

a response that is commensurate of the existing weather, fuels, and seasonal fire conditions. Responses may be to suppress the fire or simply place it in monitor status for the duration of the fire season.

Eventually there will be some form of fire activity in the Resurrection River drainage. We have no true way to predict when this will happen as the timeline for this taking place could and should be measured in tens or hundreds of years. We also have no way to predict what the effects of continued global climate change (warming or cooling) will have in this area. From a fire management perspective, the drainage should be divided into two zones. The upper drainage has had beetle impacts but these are in no way outside of the natural life process of the ecosystem, and to try to manipulate this process would be expensive and counterproductive. The only form of fuels management activity that may be considered beneficial at this time would be to start removing the accumulated fuel piles along the recreation trails from maintenance work as this fuel loading may possibly be in excess of what would have naturally accumulated over time as the beetle impacted stands fall apart. Even this form of activity to change what could be the “desired condition” is unlikely to take place.

The lower end of the drainage (below Resurrection Bridge) currently meets the desired conditions of the Seward Ranger District Fire/Fuels management group. There is neither need nor desire to try and manipulate this area away from the current condition. To make an effort to change the current condition may be counterproductive at best in regards to forest health as we have no idea how successful any fuel reduction/stand manipulation projects may be. Attempts to make changes here may actually generate more negative impacts on the health of the drainage than positive benefits. As a side note regarding fuels manipulation activities and desired conditions this drainage is used year round for numerous activities and any attempts at changing the conditions here could and will be evident for many years to come.

Fire suppression and prevention activities will still take place here and responses will be appropriate according to what is required.

From the perspective of Fire and Fuels management, the desired condition of the Resurrection River watershed will be directly tied to guidelines and conditions determined in the Chugach Forest Plan. Since each watershed on the forest is different this document would be the base guide and additional judgment would be required based on sound fire management decisions by qualified personnel. Since it can be expected that vegetation in the entire drainage will continue to grow and increase the volume of biomass, desired condition should be considered to be an evolving goal which at this time needs no input of resources or projects from fire management For the time being the portion of the drainage below the Resurrection River Bridge meets what fire management would consider desirable and therefore has no need of any actions to change it other than the occasional and infrequent fire suppression response. As for the portion of the drainage above the bridge that has been impacted by insects and has crashed this also could be considered to be the desired condition as it was a naturally occurring event. Attempts to alter the course of the natural restoration process in the vicinity of those stands will be hazardous, expensive, minimally effective, and has the potential to create additional issues if attempted. Additionally, any fuels projects focusing on significantly reducing the fuel volume would be expected to generate a high volume of smoke and likely impact the community of Seward.

Aquatic Species and Habitats

The Resurrection River Watershed contributes to the sport and commercial fishery of Resurrection Bay. Salmon species utilize Resurrection River for spawning and rearing. There is little information regarding estimates of run sizes that enter the Resurrection River.

Maintaining escapement of adult salmon to return to spawn is not only critical to maintaining stable, harvestable populations of salmon, trout, and char, but is vital to the nutrient cycling and overall

productivity of the watershed, including wildlife. Returning salmon bring unknown quantities of marine-derived nutrients such as carbon, nitrogen, and phosphorus into the watershed. Salmon carcasses provide the aquatic ecosystem with nutrients fertilizing streams, lakes, and riparian areas. Brown and black bears on the peninsula are extremely dependent on the returning salmon and help deliver nutrients to riparian areas and terrestrial habitats by dispersing carcasses during consumption and defecation (Hilderbrand et al. 2004). Studies on watersheds of the Pacific Northwest have shown that when salmon stocks are depleted and nutrients normally supplied by salmon are absent, productivity of the entire watershed is diminished (Bilby and Bisson 1996).

Aquatic invasive species are potentially the greatest threat to the aquatic resources within Resurrection River and the Watershed. Currently, Alaska Department of Fish and Game (ADF&G) Sport Fishing Division consider northern pike and Atlantic salmon the two greatest fish species of concern in Alaska. Northern pike are rapidly spreading throughout south-central Alaska and considered the highest priority threat by the Sport Fishing Division biologists. Northern pike are voracious predators and when introduced eliminate or greatly reduce native fish populations. Pike were introduced into the Susitna River drainage in the 1950s and since have severely reduced populations of rainbow trout, arctic grayling, and coho salmon.

Atlantic salmon also pose a significant threat to Resurrection River ecosystems. Atlantic salmon, if they become established, would directly compete with native fish such as Chinook and coho salmon for food and hiding cover habitat.

Additional aquatic species of concern which have not been detected in the basin to this point are the New Zealand mud snail (*Potamopyrgus antipodrium*), signal crayfish (*Pacifastacus leniusculus*), and the spiny water flea (*Bythotrephes cederstroemi*). The New Zealand mud snail is a small aquatic snail that can be easily transported via waders and wading boots, and poses a serious threat to Alaska sport fisheries. This species can propagate to extreme densities (one-half million per square meter) which can severely alter the food chain for native fishes. The signal crayfish has been found in streams on the coast of British Columbia, Canada. Once established this species usually becomes the dominant component of the streams biomass because it eats everything (plants and animals) available to it and directly and indirectly compete with native fish populations for food. The spiny water flea is a cladoceran (a small aquatic crustacean) from Europe which is also typically transported on fishing gear such as waders. Spiny water fleas are now found in the Great Lakes region and California. This invasive species displaces zooplankton populations, but is unpalatable to fish such as sockeye salmon.

The invasion of non-indigenous species costs governments of the world billions of dollars annually and has significantly impacted ecosystems, industries, and human societies. Therefore, prevention, early detection, eradication, or minimization of impacts of invasive species within the watershed is critical.

In 1999 Executive Order 13112 on Invasive Species called for increased coordination between Federal and State governments to combat nonnative (alien) species which introduction causes or is likely to cause harm to human health, the economy, or ecosystem. The ADF&G has developed an aquatic nuisance species plan to minimize their impacts to marine, estuarine, lake, and river environments.

Terrestrial Species and Habitats

The primary changes since the reference period are related to increases in human population and climate change.

Increases in Human Population

The human population increased after the establishment of Seward in 1903, and the urban renewal funded after the 1964 earthquake. Tourism was also established after 1964 to increase economic opportunity. The construction of a road to Exit Glacier and the establishment of Kenai Fjords National Park in 1980 increased interest in and access into the watershed. Increased numbers of people have affected wildlife in several ways.

Development

Prior to the early 20th century, vegetation communities existed in a more or less pristine state, affected only by natural disturbance such as fire, avalanches and seasonal flooding. After the establishment of Seward in 1903, portions of the SE quarter of the watershed have been continuously developed, clearing vegetation on private, city, state and federal lands for homes, roads, trails, and facilities. Development expanded after Kenai Fjords National Park was established and Exit Glacier Road was developed between 1965 and 1986.

Development has reduced habitat quantity and quality through habitat destruction, disturbance to wildlife from human activities, mortality to animals from DLPs and vehicle or train collisions. Examples include DLPs listed for brown bear (see brown bear section), swan mortality on Nash Road where nearby nesting swans or their young consistently get hit by cars each year, and nesting bald eagle and seabirds potentially affected by aircraft and noise near the airport.

Future development will continue to degrade wildlife habitat. Development in floodplain areas can reduce the availability of and affect the functioning of wetlands, which are important to a variety of species.

Subsistence, Hunting, and Trapping

Increasing human populations have likely increased the demand for fish and wildlife resources for food (subsistence) and furs, but this may be in a more sustained but regulated fashion due to fish and game management. How this has changed animal numbers or species composition from the past is unknown. Current management focuses on increasing moose numbers and will continue to do so.

Tourism and Recreation

Increasing human populations in the watershed and increasing in tourism in the Seward Area in the last 20-30 years has brought more people to recreate in the Kenai Fjords National Park, the Chugach National Forest and Resurrection River Trail, and along Exit Glacier Road (camping, skiing, snow machining etc).

Recreation can affect wildlife by disturbance and habitat degradation. Figure 36 shows recreation use on Forest Service Lands. Additional recreation occurs on National Park, City of Seward and State lands. Recreation activities include winter recreation (snow machining, skiing, snowshoeing, fishing), summer recreation (hiking, biking, flight seeing, fishing, recreational mining, and bird watching). Existing camps and the Resurrection River Trail runs through a brown bear core area, near swan nests and through wetlands containing moose browsing areas, bird habitat, and habitat for river otters, beaver, and a variety of wildlife species. Concentrated recreation use occurs in the Exit Glacier area and may affect species noted to occur there.

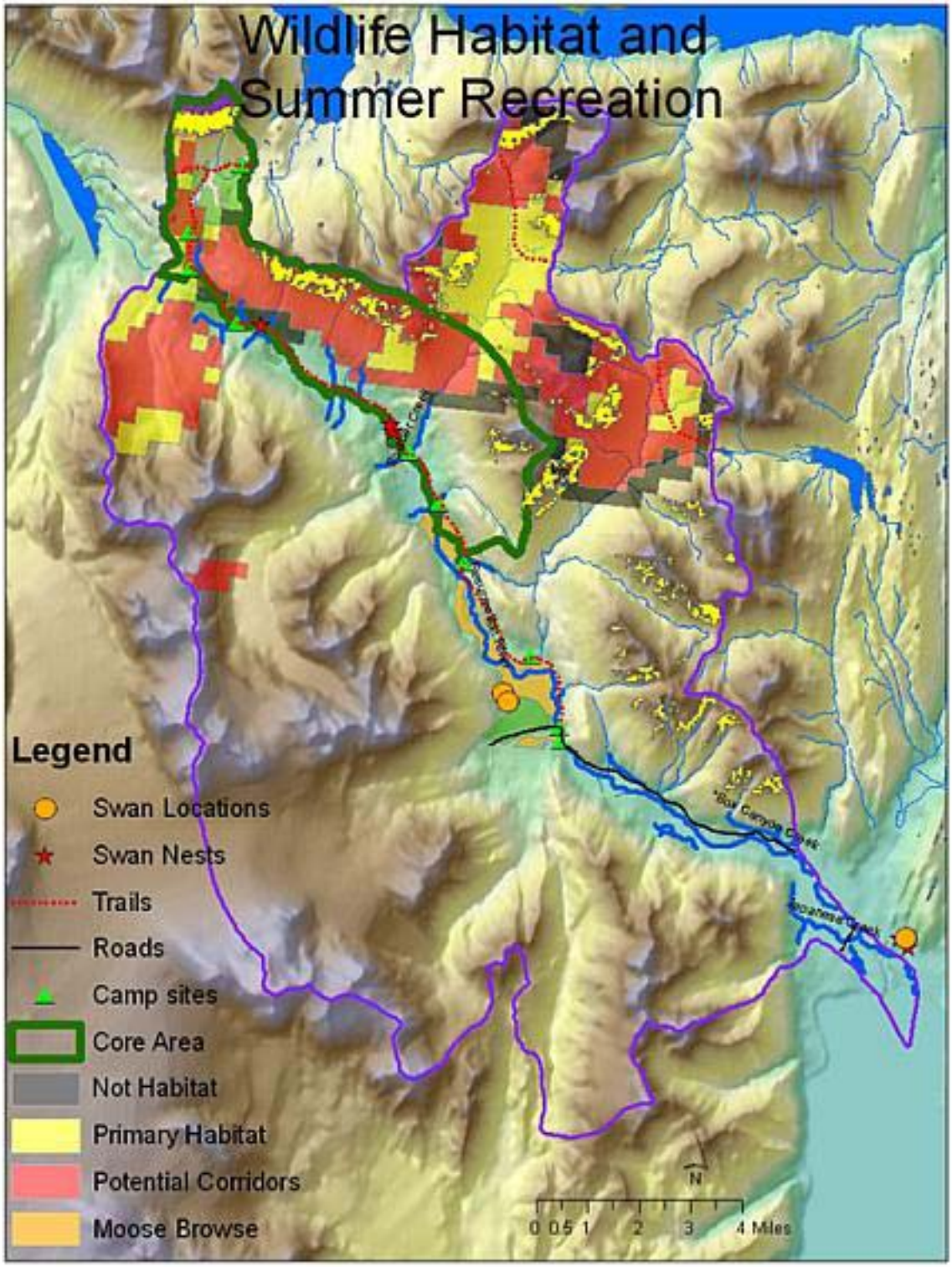

Figure 36. Wildlife Habitat and Summer Recreation

Figure 37. Transportation Corridors

Transportation Corridors

Increasing human populations have increased the needs for access and transportation, which has resulted in development of roads trails, regularly traveled corridors used by aircraft. Roads, including the Seward Highway, city roads, forest roads and Exit Glacier Road can inhibit habitat connectivity and cause mortality from vehicle collisions. Vehicles and aircraft are noisy and can disturb or displace wildlife. Trails allow access to recreationists which can disturb or displace wildlife, degrade habitat, increase fire risk in wildlife habitats. Aircraft use the Resurrection River Valley to travel to the west side of the Peninsula from Seward and for flight seeing activities near Upper Russian Lake and other areas.

Climate Change

Climatic changes have been occurring over the past several decades on the Kenai Peninsula. Although long term climate data are limited in the Resurrection River watershed, one indicator of long-term climate change is the retreat of Exit Glacier. Exit Glacier has been documented as retreating approximately 1.5 miles since 1815 (Figure 38). Records are not available before that date. It is expected that this trend of increasing temperature will continue in the future, but the magnitude of change over time is unknown.

The Kenai National Wildlife Refuge (KNWR), in cooperation with University of Alaska Fairbanks, used SNAP data (Scenario Network for Alaska Planning) to create a simple model to forecast climate change effects on vegetation through 2099 on the Kenai Peninsula (personal communication with Dawn Magness, USFWS GIS specialist, 2010).

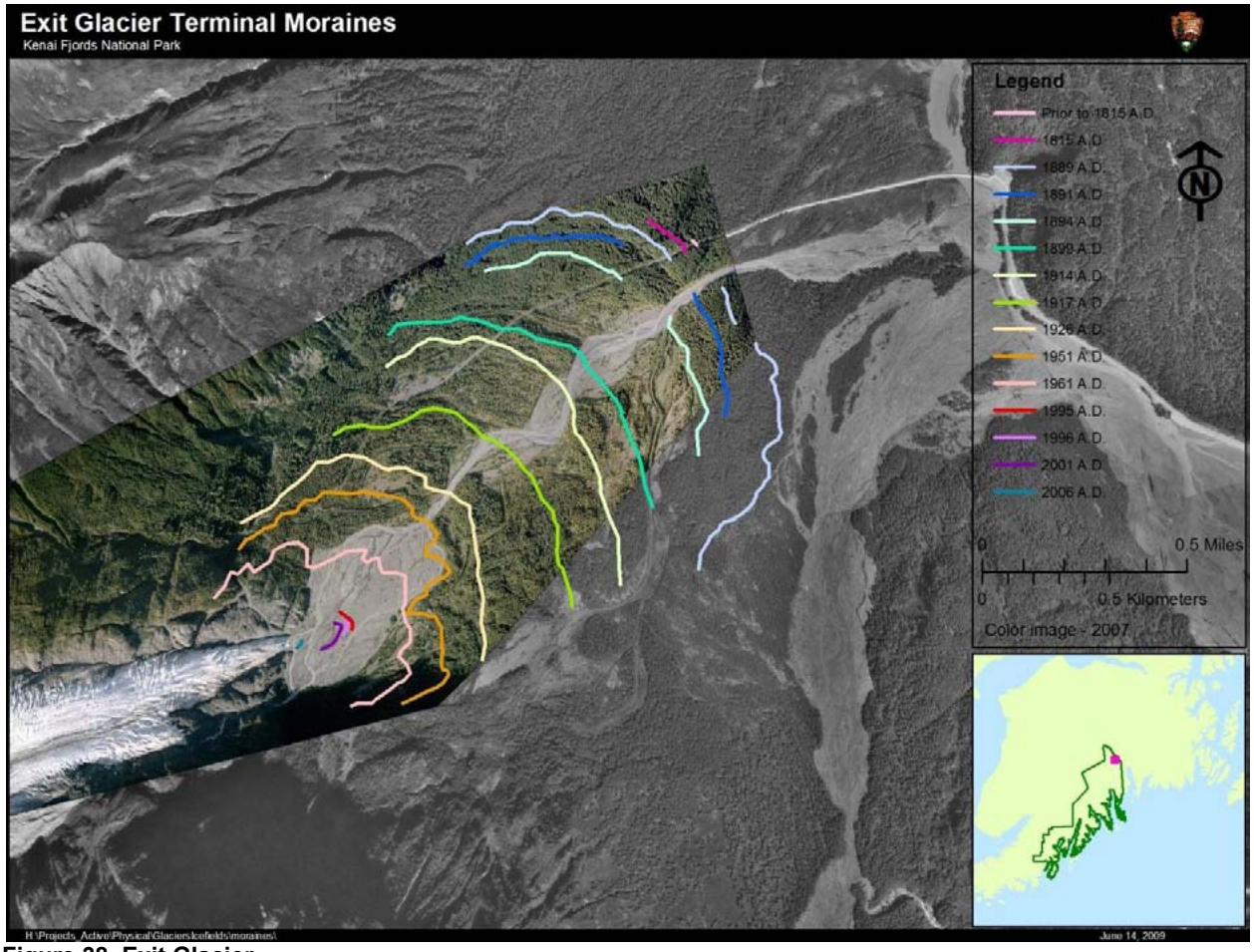

Figure 38. Exit Glacier

Figure 39. Current Biomes

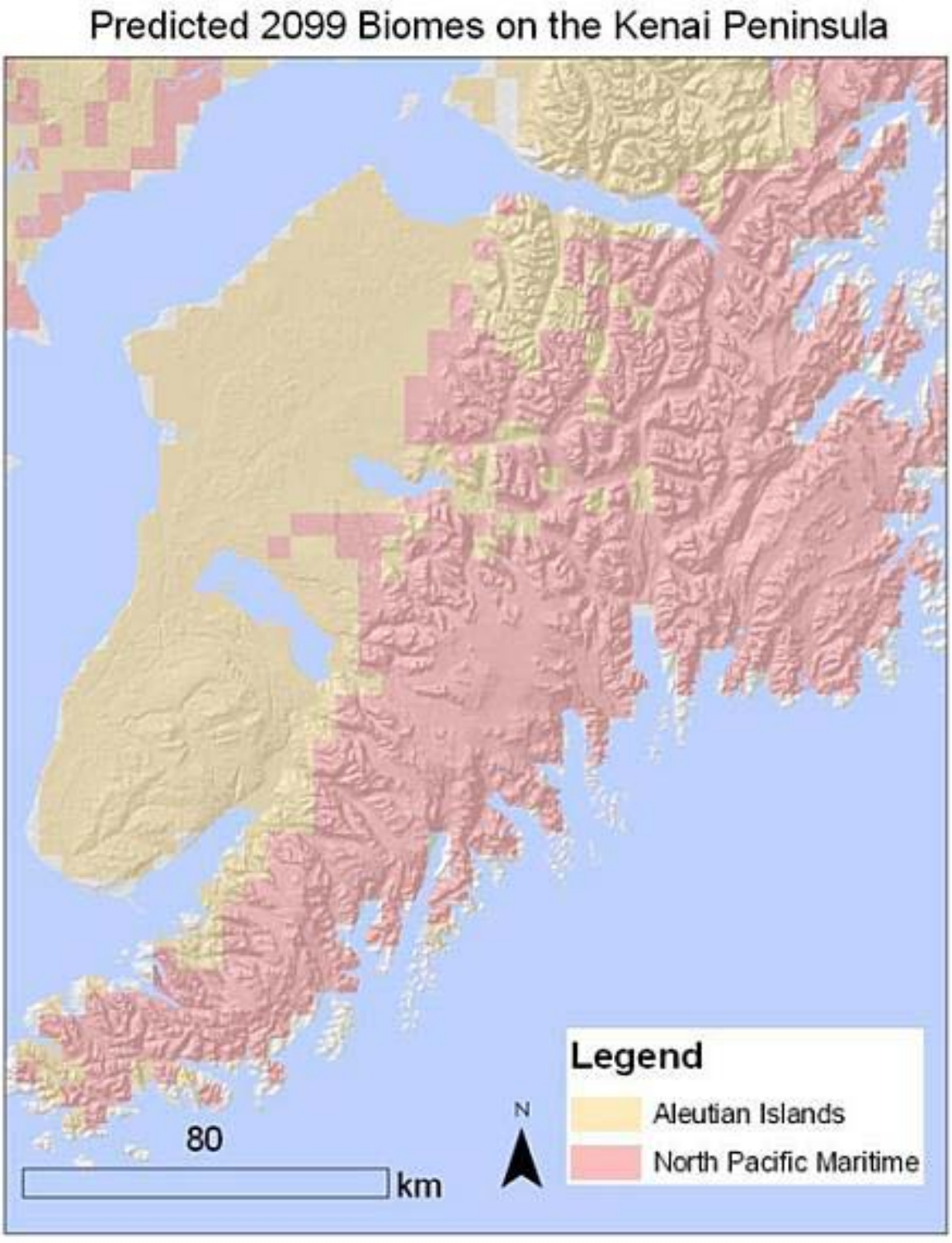

Figure 40. Predicted Biomes

Based on this model, climate change will likely affect the distribution of vegetation types on the landscape over time. Forested areas may become more abundant and alpine and sub-alpine areas less abundant. The model indicates that on the western side of the Kenai Peninsula, the wildlife refuge will change from boreal transitional forest to the Aleutian Islands Biome, losing alpine, all conifers, most hardwoods and shrubs. It will have expanding wetland-graminoid areas, herbaceous areas, and mountain hemlock. The eastern side of the Peninsula, including the Resurrection River watershed area will likely remain more stable as coastal rainforest (North Pacific Maritime Biome), but hemlock (vs. Sitka spruce) will predominate. The watershed may likely experience a loss of alpine habitat as hemlock predominates (See Figure 39 and Figure 40). On the KNWR, forested areas have been increasing at a level of 10 meters/decade.

Changes in vegetation types and structures may affect wildlife habitat, benefiting some species, and reducing habitat for others. On the KNWR, the USFWS predicts that climate change could cause extirpation of 98 percent of species, and that 2 percent would spread dramatically. It is likely that new conditions will pave the way for range expansions or reductions, or exotic species introductions (personal communication with John Morton, USFWS biologist, 2010). Warming temperatures may cause drying of water sources and wetlands, and reductions of snow and ice fields and glaciers due to melting. Exit Glacier may recede further than it is today.

Changes in biomes are predicted on the KNWR lands east and southeast of Skilak Lake from North Pacific Maritime (similar to the Resurrection River watershed) to Aleutian Island Biome by 2099. This may cause some species to migrate into the watershed to find similar habitats if they do not adapt to new habitat conditions (See Figure 36).

Although the extent of use is unknown, local reports from pilots and Godwin Glacier Dogsled Tour operators indicate that bears use snow fields or glaciers as regular travel routes and that wolves and moose are sometimes spotted. Caribou, mountain goats and Dall sheep use snow fields as refugia from insects and summer heat. If alpine areas decrease in area and availability, these species may lose habitat. The extent or significance of these effects is unknown. As alpine habitats decrease, animals may be stressed. Disease, parasites and other health issues may add further stress to alpine species. Dall sheep and mountain goats are showing evidence of disease and parasites in other areas outside the Chugach National Forest (personal communication with Tom Lohuis, ADFG). Causes and extent are unknown.

Warming may affect fish that depend on certain water temperatures for survival. Salmon in particular provide food at various stages to a wide variety of species and contribute to terrestrial nutrients. Warming temperatures may reduce suitable habitat for fish or change the species composition, creating a variety of effects on the wildlife species that depend on them for food.

Changing conditions may cause shifts in migration patterns, causing some species to leave or arrive earlier or later (personal communication with John Morton, USFWS 2010).

Climate change may have contributed to the spread of the spruce bark beetle on the Kenai Peninsula (personal communication with Ed Berg, USFWS, 2009) which has killed many of the mature and old growth trees and increased fire risk in wildlife habitat.

Spruce bark beetle outbreaks will likely continue to affect mature vegetation on a large scale. Loss of larger trees will continue to affect species that use them for nest structures such as northern goshawks and other raptors. Bark beetle impacts are more predominant in the upper portion or the watershed above the bridge, affecting spruce stands adjacent to the Resurrection River Trail. The watershed appears to be moderated by coastal temperatures and rainfall, and has had less bark beetle spread than many of the other watersheds.

Wildfires may increase in areas with beetle killed trees or wind throw, as fuel loads and temperatures increase, causing loss of mature habitats. Access to these areas will be difficult, reducing feasibility of fuel reduction treatments.

Threatened, Endangered or Sensitive Species

The watershed currently does not have threatened or endangered, or sensitive wildlife species or habitats, and it is unlikely that they occurred in the watershed during the reference period because these species are marine mammals or birds.

Management Indicator Species

Changes in brown bear populations are unknown. Populations have likely declined through habitat loss, hunting and defense of life and property (DLPs), but potential increases in fisheries and moose populations could have increased bear numbers as well. Increasing recreation in important habitat areas can cause disturbance, habitat avoidance, or increase the potential for bear human interactions. Recreation (camping, hiking, and mining) is occurring in the brown bear core area along the anadromous Resurrection River and its tributaries. The Resurrection Trail runs through the brown bear core area. Bears use a wide variety of vegetation types for traveling, feeding, resting, foraging, and denning. While bears may adapt fairly well to some of these changes, climate changes may have greater effects on some of their prey species such as fish which depend on certain water temperatures, and alpine or sub-alpine species such as mountain goats, Dall sheep, and marmots. Caribou, although very limited now in the watershed, would also experience loss of habitat.

Current populations and trends are unknown, but it is likely that with human related and climactic pressures, bear populations are and will continue to be lower than during reference conditions.

Mountain goat numbers may have been reduced with increased hunting pressure after initial European contact. Since then, with regulated hunting and game and fish management, and little development in alpine areas, goat habitat and numbers have probably remained relatively stable. Climate change may impact goats in the future by reducing habitat availability, causing stress which may reduce ability to fend off disease or parasites.

Moose may have increased after the turn of the century when human caused fires created habitat for them, but now numbers are stable to declining over time with forest succession. Management continues efforts to increase moose numbers for subsistence, recreation, and watchable wildlife. With this management emphasis, moose numbers will likely remain fairly stable over time. Spruce bark beetle impacts continue to open the canopy as trees die, offering opportunities for hardwood browse to get established. In the long term, climate change may reduce the availability of hardwood browse as hemlock becomes more dominant. If this occurs, and less browse is available, reductions in moose populations may occur. This would, in turn, affect predator populations of wolves, wolverines, and bears.

Species of Special Interest

Fur-bearer populations of bear, wolf, wolverine, lynx, river otter and other species may have decreased after European contact due to the increase in hunting and trapping, and habitat encroachment by humans. Since then, Fish and Game management does its best to regulate population changes. Continuing human development, recreation, and roads will likely continue to affect individuals negatively, and climate change may have varying effects on these species and their habitats and prey species.

Forested habitats may become more abundant, increasing habitat for northern goshawks, and some migratory birds. Changing forest types and potential impacts to fish may affect a whole suite of species

that depend on salmon. Bald eagles, for example may lose nesting habitat and experience a reduction in food.

Other Species of Interest

Other species of interest include caribou and Dall sheep. Reference conditions indicate caribou may have been more abundant in the past. At one point they were extirpated and re-introduced. While caribou population trends are stable on the Chugach National Forest, sheep populations have been declining (personal communication with Thomas Mcdonough, ADFG, 2005). Reference conditions for sheep are unknown. Climate change will likely have negative effects on both species; if warming temperatures enhance encroachment of shrubs or forest into the alpine zone.

Synthesis Summary

Human development and recreational use of the watershed may increase as human populations increase worldwide. Unchecked, this will continue to stress wildlife through disturbance and continue to reduce or degrade habitat.

Climate change, although not forecasted by current models to make a dramatic difference in the watershed compared to lands on the western side of the Kenai Peninsula. Changes on the western Kenai Peninsula may cause some wildlife to migrate into the watershed. Maintaining good habitat conditions and habitat connectivity will be important in the future to maintain habitat for species that may experience loss in other areas. Cooperative efforts should be initiated between the USFWS, NPS and Forest Service to identify habitat connectivity areas.

Heritage Resources

Information is extremely limited on Heritage Resources for the watershed. Continued work, through project work and Section 110 program management work is needed to identify new sites through new cultural resource surveys.

High-altitude resources may be affected by climate change and should be surveyed to identify these sites before potential impacts occur.

Recreation

Outdoor recreation is the fastest growing use on the national forests and grasslands across the United States, continuing a steady trend since before the 1950s (Cordell, 2004). Population has continued to be the major driver of outdoor recreation participation growth in this country (Cordell 2004). The Kenai Peninsula Borough is one of the more populated and faster growing regions of Alaska, and the rate of recreation growth on the CNF is likely to disproportionately increase the number of recreational users. Currently, well over 90 percent of Americans participate in at least one outdoor recreation activity (Cordell 2004). Estimates of recreation days occurring in forest settings from 2000–2001 show (in order) walking for pleasure; viewing/photographing natural scenery, birds, flowers, and wildlife; day hiking; sightseeing; driving for pleasure; mountain biking; and visiting a wilderness or primitive area (Cordell 2004).

Following suit with national recreation trends, recreation use in the Resurrection River Watershed has increased since the completion of the road to Exit Glacier. The completion of the road, development at Exit Glacier and the completion of the Resurrection River trail increased the number of people using the Resurrection River Watershed. In addition, all of the outwash plain offers an extended open area with easy access from the road.

Within the past 50 years, the concept of recreation itself has changed with the advancement of technology to include a wider range of recreation experiences. The development of new technology which is lighter in weight and more durable such as full-suspension mountain bikes, waterproof hiking boots, rain gear, synthetic clothing and sleeping bags, more versatile snowmachines and ATVs, four-season camping tents, backcountry telemark gear, and improved aircraft have allowed recreationists to pursue new activities in the backcountry which are longer in duration and can be carried out year-round. New technology in the form of sport-utility vehicles, larger recreation vehicles (RVs) and large motor homes has changed the original concept of front-country recreation that was envisioned for the recreationists of the 1960s and 1970s.

Many of the Forest Service recreation facilities built in the 1960s and 1970s are not adequate for today's recreationists. These are being or will eventually need to be upgraded, replaced, or rebuilt to conform with the needs and desires of today's recreationists and to comply with current Federal, State, and local laws, regulations, and guidelines. New facilities such as backcountry cabins, yurts, huts, campgrounds, and campground expansions are being built, planned, or proposed on National Forest System lands to meet the increased demand for recreation.

The overall result of new or modified recreational activities and the increase in the number of recreation visitors to the Kenai Peninsula has led to many new opportunities and challenges. The large number of visitors using the Kenai Peninsula has contributed to and changed the economy of many Kenai communities, but has also contributed to the deterioration and loss of ecological and cultural resources and facilities. For example, ATV traffic in wetlands adjacent to rivers can damage fish-rearing habitat, kill vegetation, erode soil, impact wildlife, and damage tree roots.

Resurrection River Watershed Area Recreation Trends - In general, an increase in outdoor recreation use can be assumed as the population grows. Alaska residents are also known for their propensity to recreate throughout the State. Alaska is also a destination location for many recreational enthusiasts from out of State. The Resurrection River Watershed will continue to experience moderate recreation growth, especially in the areas adjacent to the road, trail and within National Park Service lands at Exit Glacier.

Resurrection River Recreation Conflicts - Generally, the main sources of recreation conflicts are adverse interactions between different user groups (i.e., Skiers and Snowmachiners). These conflicts can occur because recreation users feel either threatened or their expectations in the experience diminished. The prevailing example of recreation conflict in the Resurrection River Watershed is in the winter between snowmachiners and nonmotorized users. Other conflicts between users are bicycles and vehicles on the road and mountain bikers and hikers on the Forest Service trails.

Desired Condition, Opportunities, Management Strategies, Data Gaps, Monitoring and Research Needs

This chapter discusses desired future conditions, considering the differences between reference and current conditions (beginning on pages 32 and 96 respectively). Desired future conditions consider what is feasible today and current management direction. Opportunities, management strategies, data gaps, and monitoring and research needs are presented for each desired future condition as means to achieve the desired condition.

The following incorporates management direction from the Revised Forest Plan, (page 3-13) (USDA Forest Service, 2002a).

Table 23. Opportunities, management strategies, data gaps, and monitoring and research needs for each desired future condition by resource

Opportunity	Data Gap	Management Strategies	Monitoring and Research Needs
Lands			
▪ The desired condition for the landscape area is to remain in federal ownership between the USDA Forest Service and the USDI Park Service.			
There may be some opportunities to more precisely define the boundary between the USDA Forest Service and the USDI Park Service. As described above, using the Resurrection River as the boundary does not allow for a precise delineation between the ownership of these two federal agencies.	None identified.	In order to create a more precise boundary between the USDA Forest Service and the USDI Park Service, consultation between these two federal agencies is necessary. In addition, it may be necessary to utilize a different boundary than the Resurrection River because it changes from year to year.	In order to delineate a concrete boundary between the USDA Forest Service and USDI Park Service, it may be necessary to research or survey a potential boundary that is more static than Resurrection River.
Geology, Minerals, and Soils			
Geology and Minerals			
▪ All lands not expressly withdrawn from mineral entry for recreation areas, campgrounds and similar developed sites are and should remain open to mineral entry. **▪ Assess mineral materials sites if a need is identified.**			
National Forest lands within the watershed areopen to mineral entry and location (locatable minerals) if not expressly withdrawn. Opportunities exist for development of sand & gravel and rock, primarily in the roaded valleys to support local residents and local infrastructure projects.	Develop 10 years mineral material management plan for roaded areas of the Kenai Peninsula.	Process locatable submittals promptly according to 36 CR 228A and FSM 2810 regulations. Consider all reasonable requests for Mineral Materials under 36 CFR 228C and FSM 2850 regulations.	Investigate possible sites for development of mineral materials to support the needs of local residents and infrastructure construction and maintenance.
Soils			
▪ Soil resources will be the result of natural processes. Soil resources will provide natural soil ecosystem functions, processes, and services such as soil organism habitat, biogeochemical cycles, watershed stability, water storage and release, and above and below ground biodiversity as compared to a natural reference.			
Work with other Forest programs, agencies, and landowners to manage soil resources to maintain or improve soil quality and function. Use models including WEPP, CENTURY, RAVE, SOIL, and others to predict, manage and/or mitigate erosion, soil carbon, nutrient cycling, pesticide behavior and fate, movement of water, gases, and solutes associated with projects. Provide interpretations for uses, responses, resiliency and restoration to support project design.	The assessment area lacks soil resource inventory of the FS National Hierarchical Framework of Ecological Units for the land type phase and/or soil management units. The other existing inventory units including land types do not meet TEUI or NCSS standards.	Design projects to meet Soil Quality Standards (SQS), soil and water BMP's, mitigation, and soil management prescriptions that are documented in ecological assessments (CE, EA, EIS). Watershed restoration activities will improve the characters and functions of the soil. Restoration activities for other resources will cause no harm or will cause net improvement to soil resources. Conduct land stability analysis as prescribed in appendix A of the Chugach Forest Plan.	Inventory, map and monitor any mass-wasting areas to get baseline type, extent and rates of movement/change/effects. Monitor soil quality parameters associated with project design and implementation. Monitor vadose zone and wetlands associated with restoration projects for proper hydric soil classification and function. Model the soil carbon pool as a baseline monitoring reference for climate change.

Opportunity	Data Gap	Management Strategies	Monitoring and Research Needs
Hydrology			
▪ The condition of water resources in the watershed will result primarily from natural processes. Stream channels throughout the watershed will function naturally in terms of hydrologic function, bank stability, riparian condition, water quality, and aquatic habitat. ▪ Streams and other water bodies in the watershed will have acceptable water quality, as defined by the Alaska State water quality standards (Alaska Department of Environmental Conservation, 2009). ▪ A controlled balance will exist between allowing natural stream processes to occur and controlling these processes to protect human developments in the lower portion of the watershed. ▪ Contributions to greenhouse gas emissions will remain limited, and riparian ecosystems will have high resiliency to the effects associated with climate change.			
None at this time	▪ Long term streamflow data for streams in the watershed are needed for assessing flood hazards and the long term impacts of climate change. ▪ The National Hydrography Dataset (NHD) is inaccurate in places and needs to be edited.	▪ Ensure that Forest Service projects comply with all applicable Best Management Practices (BMPs), as defined in the R10 Soil and Water Conservation Handbook (USDA Forest Service, Alaska Region, 2006), to protect water quality. ▪ Work with State and local organizations on developing the best ways to address the flooding issues in the Seward area while retaining natural stream function.	▪ Work with State and local organizations to better understand flood dynamics and stream channel function in the area, and how floods may impact developed areas downstream. ▪ Establish long-term gauging stations in the watershed to measure streamflow and water quality parameters to better determine hydrologic changes that are occurring as a result of climate change.
Vegetation and Ecology			
▪ Backcountry - Ecological processes, largely unaffected by human activity, dominate Backcountry Management Areas ▪ Brown Bear Core - In landscapes with multiple aspen or birch stands, manage for a mix of structural stages. Conserve the structural diversity of multi-storied stands. Design vegetation management activities, including commercial timber harvest to maintain or enhance brown bear feeding areas and travel corridors and to avoid disturbance to brown bears. ▪ Fish, Wildlife, & Recreation - provide a variety of habitats for fish and wildlife species and year-round recreational opportunities in both developed and dispersed settings. ▪ Minerals Management Area – managed for the exploration, development, extraction, and processing of locatable, leasable, and salable minerals. ▪ Fish and Wildlife Conservation – managed to emphasize the conservation of specific fish and wildlife habitats.			
There may be some opportunities to meet desired conditions by creating hardwood stands in brown bear core area. Ability to achieve desired condition for the Fish, Wildlife, and Recreation Management Area is unknown due to missing vegetation data for a large portion of this MA within the watershed.		▪ To create hardwood stands, even- aged regeneration methods should be employed. ▪ Consult with a wildlife biologist to determine needs for brown bear core area.	▪ Monitor the status of alder in the watershed and, if it is decreasing, identify what is replacing it. The answer to this question will help determine what the consequences may be for stand development if alder is decreasing. ▪ Monitor for gypsy moths due to proximity of the Exit Glacier area of Kenai Fjords National Park. ▪ If regeneration harvest occurs in this watershed, stocking surveys must be completed. Stocking and survival surveys must be completed for any sites that are planted.

Opportunity	Data Gap	Management Strategies	Monitoring and Research Needs
Botany and Weeds			
▪ The desired condition would be natural habitats in proportions that would exist under natural processes.			
With the revision of the Region 10 sensitive species list in 2009, there is an opportunity to update the bioenvironmental model. New data and updated tools can be used to develop sensitive species conservation assessments, which are important tools used in the management and conservation of rare species.	• Most of the area has not been surveyed for sensitive plants.	• Revise the bioenvironmental model to reflect recent changes to the R10 Sensitive Species List. Conduct sensitive plant surveys in areas with high potential habitat based on a revised bioenvironmental model.	Research needs include additional surveys to better understand the presence and distribution of sensitive species in the landscape area.
▪ The desired condition would be a landscape where non-native plants remain restricted to areas of human disturbance and do not encroach into natural habitats.			
• Prevent non-native plant species from spreading away from areas of human disturbance, therefore keeping natural areas free of non-native species. .	Trend data of known non-native plant infestations.	• Develop management strategies based on the CNF Invasive Plant Management Plan (2005) and the Guide to Prevention Practices (USDA Forest Service 2001). ▪ Control existing populations, which can continue to spread and new infestations can become established. Reducing the spread requires a timely, adaptive, and integrated approach.	• Monitoring and annual evaluation should be initiated. • Established infestations should be inventoried and managed based on objectives and priorities.

Opportunity	Data Gap	Management Strategies	Monitoring and Research Needs
Fire and Fuels			
▪ The predominant conditions on the Chugach National Forest will be those that result from natural processes. Conditions that result from active management or restoration will be present in selected locations (USDA Forest Service, Chugach National Forest, 2002a, pg. 3-13).			
Apply Fire Regime Condition Class (FRCC) or other models to determine fire risk, fire return intervals, potential fire spread, and strategies to deal with fire in the watershed. Future options for the planning area should include a fire use program within the limited suppression boundary. This will allow natural fire to play a role in shaping the ecosystem while reducing impacts and costs associated with fire suppression activities. Fire prevention signs at trail heads and road side stops could raise awareness of fire danger with the public.	▪ Fire regime condition class (FRCC) mapping of the project area to ascertain departures from historic levels does not exist. ▪ Fuel characteristic classification system (FCCS) mapping for the project area to determine the rate of spread and severity of fire within the project area does not exist. ▪ Stand data for input into fire behavior models and future treatment areas near highways and homes do not exist. ▪ Current digital elevation models and 1-meter digital color orthoquads are needed for future limited fire suppression strategies or wildland fire use for resource benefit planning. ▪ Accurate weather observations and patterns are needed within the Resurrection River Watershed to manage fire under appropriate fire suppression strategies.	▪ Restoration activities, such as prescribed fire and mechanical treatments, in these areas and small-scale forest management activities along the road corridors will create opportunities for the utilization of forest products. ▪ Prescribed fires could occur on a limited basis each year for fuel reduction, improvement of wildlife habitat and restoration to desired vegetative conditions provided appropriate funding can be obtained. Catastrophic wildland fires are projected to be infrequent and, when they occur, will most likely be within major travel corridors and other centers of human activity. Smoke levels will be within state standards for particulate material, except when catastrophic fires occur (USDA Forest Service, Chugach National Forest 2002a, pg. 3-15).	▪ Monitor the effects of increased use and fire occurrence within the watershed. ▪ Monitor first order and secondary fire effects of prescribed and natural fire within the project area.

Opportunity	Data Gap	Management Strategies	Monitoring and Research Needs
Aquatic Species and Habitats			
▪ Follow the Forest Management Plan for the Management Area Prescriptions such as: ▪ Brown Bear Core Area Management Area which states that fish habitat improvements should focus on restoring anadromous habitat and improvements to spawning areas with the Brown Bear Core Area with an emphasis that such improvements will not increase human-bear conflicts. ▪ Backcountry Management Area states that modifications to fish habitat improvements may be present but must blend into the area's natural features. ▪ Fish and Wildlife Conservation Area Management Area states that projects to enhance or restore fish habitat are encouraged and that these projects may provide for watchable wildlife opportunities. Fish and Wildlife Conservation Areas will also provide opportunities for solitude. ▪ Fish and Wildlife Recreation Management Area states management of fish and wildlife habitats will emphasize maintenance of genetic diversity of fish, the enhancement of fish habitat important to sport, commercial or subsistence fisheries.			
▪ Opportunities to explore the current spawning and rearing habitat for the five species salmon exist within this watershed. ▪ Protect and maintain any existing high quality riparian and aquatic habitats and restore degraded habitat within the watershed. ▪ Build partnerships with the City of Seward, Resurrection Bay Conservation Alliance, Alaska Department of Fish and Game, Kenai Fjords National Park, Fish and Wildlife Service, Alaska Sealife Center and the Seward Chamber of Commerce to collect data and improve important salmon habitat benefitting the sport and commercial fisheries of the area.	▪ Many data gaps exits within this watershed. ▪ Coho salmon are of great economic benefit to the City of Seward and little is known about the coho salmon spawning and rearing habitat within the Watershed. ▪ Most of the sport fishery has been supplemented by hatchery raised fish over the past twenty plus years so little is known about the genetic integrity of the coho fishery. ▪ Fish and aquatic species distribution within the watershed is speculative. ▪ Side-channel rearing habitat availability for salmonid species and invertebrate species distribution.	▪ Conduct a reach specific fish distribution and rehabilitation assessment of main stem, tributaries and side channels. ▪ Determine restoration needs within the watershed based on aquatic habitat survey. ▪ Develop a site specific plan of restoration or rehabilitation. ▪ Determine fish distribution for each tributary and identify introduced and/or invasive invertebrate or vertebrate species. ▪ Assess fish passage needs within the watershed within tributaries.	▪ How many resident fish (Dolly Varden and/or Rainbow Trout) are harvested in the watershed. ▪ What invasive species occur within the watershed, for example; Atlantic salmon, New Zealand mud snail, northern pike? ▪ Is erosion occurring due to riparian trampling? ▪ What percentage of the Resurrection River Watershed coho and sockeye are intercepted by sport, commercial and/or subsistence fisheries?

<table>
<tr><th>Opportunity</th><th>Data Gap</th><th>Management Strategies</th><th>Monitoring and Research Needs</th></tr>
<tr><td colspan="4">Terrestrial Species and Habitats</td></tr>
<tr><td colspan="4">
▪ Bear/ human interactions are minimal, and the potential for wildlife habituation of bears is low throughout the watershed and particularly in the brown bear core area.
▪ Disturbance to wildlife (bears, sheep, goats) from aircraft and other recreation activities is minimal or within an acceptable range.
▪ Wildlife populations are healthy and support a variety of uses including watching wildlife, subsistence, sport hunting, and other values.
▪ A diversity of vegetation types and structures exists to provide a wide range of habitats for wildlife in approximate amounts as listed below.
<table>
<tr><th></th><th>Mature/Old Growth</th><th>Pole and Young Saw timber</th><th>Seedling/Saplings</th></tr>
<tr><td>Conifers</td><td>60%</td><td>20%</td><td>20%</td></tr>
<tr><td>Hardwoods</td><td>20%</td><td>20%</td><td>60%</td></tr>
</table>
▪ Early seral hardwoods exist away (1/4 mile) from roads and the highway, and within or adjacent to moose winter range.
▪ The risk of loss of late seral conifer habitat due to fire is minimal.
</td></tr>
<tr><td>▪ Actively manage habitat within the Brown Bear Core Management Area to meet the population objectives for brown bears and reduce dangerous encounters between humans and bears in cooperation with NPS and USFWS.
▪ Plan for habitat connectivity from the forest and park to the USFWS lands to provide travel corridors for species that may try to migrate to other areas as the west side of the peninsula becomes warmer, drier, and potentially changes biomes.
▪ Move current vegetation and structure toward desired condition where feasible and economical by regenerating spruce and hardwoods. Focus in areas of dead trees (5470 acres) and look for opportunities to meet fuel reduction objectives. Expand moose winter range forage availability.
▪</td><td>▪ Brown bear population size and structure, spring foraging habitat for sows with cubs, summer feeding habitat and winter denning habitat need to be identified or verified.
▪ Extent and impacts that floatplanes and other flight seeing activities are having on wildlife, particularly bears, sheep and goats is unknown.
▪ Current populations and trends for salmon in the watershed.
▪ Current Recreation use in the brown bear core area, level and trends of bear/human interactions.
▪ Snow machine use levels and potential impacts to mountain goats.
▪ Is alpine habitat in the watershed shrinking in response to climate change?
▪</td><td>▪ Increases bear awareness with interpretation, education, and signs. Use Vantastic Van at Resurrection River Trailhead or Exit Glacier Overlook. Provide additional bear-proof food lockers in backcountry areas.
▪ Maintain lower levels of recreation use in the bear core area by declining to fix damaged bridge sections and through minimal trail maintenance.
▪ Improve visibility for bears along the first several miles of the Resurrection River Trail through vegetation management where the greatest recreation use occurs.
▪ In beetle kill areas, enhance hardwood regeneration on up to 344 acres outside the brown bear core near moose winter range. Enhance spruce regeneration on up to 2660 acres in the brown bear core to help maintained screened foraging areas for bears.
▪ Reduce fuels near trails and other human use areas to minimize fire risk to surrounding wildlife habitat.
▪ Inventory and monitor MIS and SSI species and potential impacts from recreational activities In cooperation with NPS.
▪ Increase awareness of potential impacts from aircraft on mountain goat, Dall sheep, and brown bears with outfitter/ guides, air taxis, and flight instructors, and ask for voluntary compliance with recommendations.</td><td>▪ Monitor current summer and winter recreation use to determine trends, and acceptable limits within the brown bear core area.
▪ Monitor current aircraft (flight seeing and float planes) and snow machine use in the watershed, and identify potential disturbance to wildlife.
▪ Monitor changes in alpine habitat over time to determine if climate change forecasts are accurate.
▪ Monitor current nutritional condition, and health, and population trends of Dall sheep and mountain goats in the watershed?
▪</td></tr>
</table>

Opportunity	Data Gap	Management Strategies	Monitoring and Research Needs
Heritage			
▪ **Greater coverage of the landscape assessment area by cultural resource surveys. More cultural sites evaluated for National Register eligibility.**			
Project work (section 106), general research (section 110), monitoring (NFIM).	Less than 1% of landscape assessment area surveyed for cultural resources. Need information on where Forest users are focused to identify where negative effects to cultural resources are most likely to occur.	Forest Plan site management prescriptions.	Need greater survey coverage.
Recreation			
For lands away from the road system but outside of the Brown Bear Core Area, we are to manage those lands for undeveloped, dispersed non-motorized recreation during the snow free months. We can build trails and cabins but at this time there is little potential for any developments. We will continue to maintain the Resurrection River Trail at a level 3 to Martin Creek and work on getting a bridge over Martin Creek to get the Resurrection River Cabin back up as a public use cabin. In Brown Bear Core no development will take place but we will maintain the Resurrection River Trail. Lands adjacent to the road system we will manage for dispersed recreation associated to the road travel. Camping will be limited to 14 consecutive days. We will maintain the Exit Glacier Overlook and Resurrection River Trailhead and work with other agencies to construct a bike path adjacent to the road. No other facilities are planned. This area is managed as a non-motorized area in the summer and a motorized areas in the winter.			
The only foreseeable recreational opportunity in the development is a potential bike path that would run from the Seward Highway to Exit Glacier. The Park Service has obtained some money this year to start an environmental assessment on this project.	▪ The Forest Plan guides us in our management strategies. All activities will be designed to meet the Scenic Integrity Objectives as mapped. Management Activities will follow the Recreation Opportunity Spectrum Class as mapped. Continue to work with Law Enforcement, the State Troopers, and Park Rangers to police campers and day-uses during peak use period, especially 4th of July weekends. There is a need to collect more winter use data.		

Recommendations

Lands

At present, the boundary between the USDA Forest Service and the USDI Park Service is not well defined or mapped. While the boundary is unclear, there has been no conflict or management problem because there has been no active management along the border. If more active management is planned, the boundary may need to be more formally identified through survey.

Geology Minerals and Soil

Geology and Minerals

Mineral Development

Any proposals for locatable minerals must be receive a prompt response and proactive environmental analysis to allow reasonable, logically sequenced operations.

It is recommended that commercial requests for disposal of mineral material sales be contracted if private resources are not readily available and that free-use requests should be permitted.

Soils

- Invasive weed species are a negative impact to soil quality and function, particularly soil biology and chemistry. The threat of invasives is growing because of increased population using the assessment area and because of climate change which is generally more favorable to weeds compared to native species. Aggressive preventative and treatment actions are recommended to maintain soil quality and species diversity. Reference the Chugach NF Invasive Plant Management plan which provides appropriate management actions.
- Trails are an important capital investment and recreational resource in the assessment area. To protect the soil and geomorphic surface, trails need to be maintained properly. One of the most overlooked trail maintenance actions is erosion prevention. Historically, once eroded material backs up against or fills in behind a water bar, they have been cleaned. Rather than preventing erosion and stabilizing the tread, cleaning water bars and dips has the opposite effect of continuing erosion and destabilizing the soil surface. The solution to this situation is that water bars or dips should stay in place and should not be "cleaned". When the water bars' capacity is filled, rather than cleaning, one or more new, additional water bar(s) should be installed.
- Trails should be slightly out-sloped wherever topography lends the opportunity, which is nearly always. About 0.5 to 3 percent minimum outslope is all that is necessary to maintain the tread surface. Outsloping also negates the need to construct waterbars.
- Trail tread width and clearing width should be kept to the lowest minimum standard to serve the intended use. Single-track trails minimize erosion and weed invasion.
- Trail relocation, and trail construction needs to be on the most appropriate land type and the most appropriate position on a given land type relative to location and grade to avoid unnecessary disturbance, erosion, and potential for weed establishment.
- Vegetation treatment that involves heavy equipment needs to follow the soil quality standards. There are exceptions that can be recommended by the soil scientist, for example, on particular soils with histic surfaces and in certain cover types.

- Vegetation treatment using prescribed fire generally has few harmful effects to soils with the potential exception of organic soils. Prescribed fires should be scheduled when the burn will not consume humic soils, i.e., organics below the surface litter layer (Oi, Oe horizons).
- Generally, when management actions such as mining are expected to disturb the soil, as much topsoil as possible should always be saved for finishing the project after disturbance. If topsoil is available, it should be spread and then covered with appropriate mulch, but generally not seeded or fertilized. There should be plenty of seed bank of native plants in the upper layers of topsoil to preclude the need for seeding. Fertilizing native topsoil can often substantially alter the habitat for native plants, which in turn can alter the composition and frequency of natives. Of course, there will be other occasions and situations where fertilizing may be appropriate and desirable. Topsoil should be handled and stored to maintain most of its original properties, including the soil biology and seed bank. There are specific techniques in handling topsoil for restoration use in order to limit denitrification, maintain desirable soil biology, seed bank, and physical properties. Consult with the soil scientist when developing mining operating plans and restoration. Store topsoil depending on the kind of soil, season(s) and length of time that it will be stored. Contact the soil scientist when contemplating and designing other land-disturbing projects.
- Most terrestrial carbon is below-ground. Manage soil and vegetation resources and use soil quality standards to maintain or increase the below-ground carbon sink and sequester the maximum carbon for long time-frames.
- Inventory landslide and landslide prone areas using aerial photography, satellite imagery, and field-checking and mapping. Determine current and recent rates of movement by standard, published methods or adaptations of standard methods as appropriate. Store this data in NRIS, NASIS, or other appropriate FS corporate database.
- Inventory land types and soils according to the National Hierarchy for land system inventory, TEUI and NCSS standards. Store this data in NRIS and NASIS.
- Set up landslide mass-wasting monitoring to track any existing or potential slope failure.
- Monitor vadose zone and wetlands associated with restoration for the correct hydric soil classification and function.
- Most of the terrestrial carbon sink is below ground. Model the soil carbon pool as a baseline monitoring reference for climate change. Monitor soil respiration to model ecosystem respiration and carbon cycle.

Hydrology

The following recommendations apply to water resources concerns in the Resurrection River watershed, as related to the issues and key questions presented in this analysis.

- During various projects involving heavy equipment, use established methods to reduce emissions of greenhouse gases that may contribute to climate change. Implement activities that would improve the ability of the Forest to sequester carbon and improve the resiliency of the Forest to the impacts of climate change.
- Develop a multi-watershed strategy for the Kenai Peninsula to collect baseline data that would be used to evaluate the effects of climate change on various resources, including streamflows and water quality.
- Update the National Hydrography Dataset (NHD) streams layer in the watershed based on recent aerial photography.

Vegetation and Ecology

- Work with Forest Health Protection/Alaska DNR to monitor for gypsy moths.
- Work with Forest Health Protection to monitor the status of alder mortality.
- Consult with wildlife biologist to determine if needs for brown bear habitat are being met within Brown Bear Core Management Area.
- For any vegetation projects within this area where merchantable wood is produced, wood should be utilized.

Botany and Weeds

Non-native Plants

Since non-native plants are present only in areas of human disturbance, the following recommendations would help work towards the desired condition.

- Implement the seven prevention measures listed in the above section.
- Conduct fine-scale inventory of non-native plants in areas of human disturbance in order to plan efficient control projects using integrated weed management techniques. The fine-scale inventory would complement existing inventory and would provide more detailed information on infestations.
- Continue inventory and monitoring to detect new populations of non-native plants. If any new populations are detected, they should be controlled immediately before the infestation becomes well-established. Next to prevention, early detection and rapid response are the most efficient and effective means of control.

Sensitive and Rare Plants

There is very little data regarding sensitive and rare plants within the Resurrection River landscape assessment area. The following recommendations would increase our knowledge of sensitive plants and would help manage for the conservation of these species.

- Conduct systematic surveys for sensitive species in order to determine presence, abundance, and distribution.
- Use new data to help refine and validate the habitat diversity/ bioenvironmental model. In addition, the model can be updated to include the new sensitive species list.
- New data may be used to support a new conservation assessment for a Region 10 sensitive species.

Fire and Fuels

At this time the Fire/Fuels Management organization on the Seward RD has no recommendations or plans to implement any form of fuels reduction treatments in the Resurrection River Analysis area. Any form of fuel reduction done in the lower drainage would likely have long standing negative effects on the existing vegetation as the healthy spruce present are subjected to the effects of piling and burning activity generated fuels. Additionally, any fuels reduction treatments in the lower drainage would be in close proximity to Exit Glacier road and would impact travel, especially when conditions were conducive to removal/burning of generated material.

This decision may change when and if local cooperating fire departments complete Community Wildfire Protection Plans. Completion of these plans would allow the Chugach NF to plan and participate in fuel reduction projects located in close proximity to the WUI (wildland urban interface) boundaries associated

with both the Seward Fire Department and the Bear Creek Volunteer Fire Department response zones located near the mouth of the Resurrection River drainage.

The section of Resurrection River above the trailhead parking area could present the possibility to do some form of fuel treatment as there are several thousand acres of standing dead spruce present from the last beetle infestation. The exact amount is not known at this time nor is the true condition of the impacted stands known as fire management personnel have not conducted any form of on the ground surveys. Recreation personnel are continually removing blow down trees from the trail that runs through this area and those actions have and will generate a considerable amount of fuel along the trail which eventually may need to be addressed. However, the impacted areas are several miles from the nearest access and the logistical considerations of supporting any kind of fuel reduction operations there are prohibitive. Aside from the cost per acre to perform the work, which is projected and expected to be very high, the issues arise of safety for personnel working so far away from any ground transport access at a time of season when quick egress to participate in fire suppression activities when called limits where the district fire organization can work. An operation in this area would require some form of aviation support which may or may not be available during fire season. The possibility of staying on site could be addressed as an alternative to transporting employees or walking them in but the most heavily impacted areas are in brown bear core habitat which generates additional concerns for bear impacts, habituation, and bear/human interaction.

From a fuels standpoint, the most cost effective form of treatment would be either the application of large scale prescribed fire or, if it were to take place, utilization of an unplanned ignition due to the limited suppression zone the impacted stands are in. For a prescribed fire operation to be planned and successful would require fire application at the peak of dryness during the summer months. This creates the issue of additional resource availability during what would likely be an active fire season when contingency forces are not able to commit to assisting. Also, when and if fuel moistures did get to percentages conducive to large scale fire applications this area would be tough to quickly access without having fire personnel on site for the duration of the project.

The Fire/Fuels organization on the Seward RD would continue to be a key contributor to the success of any projects projected to take place in this analysis area should the need for additional assistance or expertise arise. Any projects that could take place in this watershed will be subject to oversight and conducted under the guidelines, regulations, and considerations set forth in the most recent version of the Chugach National Forest revised Land and Resource Management Plan, Fire and Fuels Management.

Aquatic Species and Habitats

Recommendations

There is a need for baseline data collection for spawning and rearing habitat and species occurrence for Resurrection River Watershed.

Terrestrial Species and Habitats

Manage habitat within the Brown Bear Core Management Area to meet the population objectives for brown bears and reduce dangerous encounters between humans and bears.

- Develop a monitoring program with SRD Recreation and NPS and USFWS that will identify current recreation use, and levels and trends of bear/human interactions. Start with existing trail and cabin data to determine if information from these sources will be adequate. If not, develop a plan for

gathering this information. The plan should identify threshold levels of interactions to trigger management action.

- Identify areas along the Resurrection River Trail that might benefit by vegetation treatments that to improve visibility for brown bears, while maintaining screened foraging habitat for them.
- Monitor current aircraft use in the watershed to identify potential disturbance and cumulative effects to bears, mountain goats and Dall sheep in the brown bear core area.
- Monitor DLP numbers of brown bears and work with RCBA to increase awareness of using bear proof garbage cans.
- Promote vegetative diversity to meet desired conditions by promoting early seral hardwoods and conifers. Promote moose hardwood browse outside the brown bear core near existing moose winter range by treating dead spruce and promoting early seral birch or aspen. Access will be difficult and opportunities weighed against costs. Approximately 5,469 acres of predominantly dead spruce exist and are shown in Figure 41. Work within these areas to regenerate spruce on up to 2,660 acres. Hardwood regeneration can be promoted on up to 344 acres. Data shows that mountain hemlock could be regenerated as well, but with climate change forecasts for mountain hemlock becoming predominant in the future, we could let nature do it for us and not actively manage for it.

Develop a joint climate change monitoring program with USFWS and NPS to monitor changes in alpine habitats and species as predicted by the USFWS model. If alpine areas start to shrink as predicted, look for ways to reduce stress on alpine species from other sources such as recreation. Develop large scale habitat connectivity maps to manage for species migrations and adaptations.

Table 24. Promoting Vegetative Diversity

Current Vegetation Type and Structure	Acres	Existing Percent of total acres	Desired Percent of Total Acres	Change Needed in Percent	Treatment to reach Desired Condition
Spruce					Regenerate spruce in areas that are currently late seral with primarily dead trees on up to 2660 acres
early seral	0	0	20	20	
mid seral	203	3	20	17	
late seral	6,985	97	60	-37	
Total	7,188	100			
Aspen, Aspen/Birch					Increase early seral hardwoods on up to 344 acres.
early seral	952	44	60	16	
mid seral	410	19	20	1	
late seral	789	37	20	-17	
Total	2,151	100	100		
Mountain Hemlock					Regenerate some mountain hemlock in pole stands on up to 1135 acres. Or leave it and wait for climate change to promote hemlock.
Mountain Hemlock - seedling/sapling	0	0	20	20	
Mountain Hemlock - Pole	3,180	56	20	-36	
Mountain Hemlock - Large	2,497	44	60	16	
Total	5,677	100			

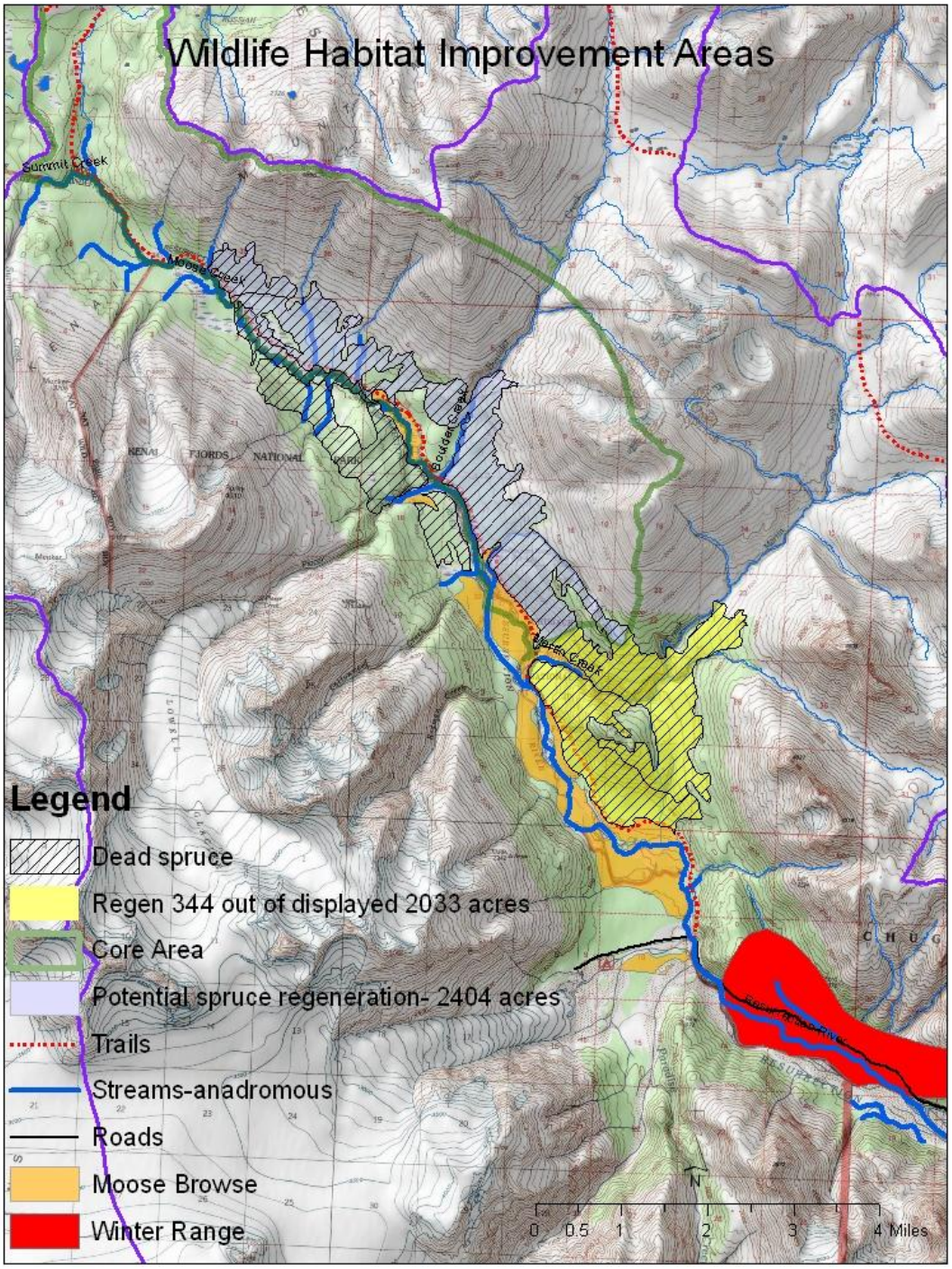

Figure 41. Potential Wildlife habitat Improvement Areas

Heritage Resources

Continue work, through project work and Section 110 program management work, to identify new sites through new cultural resource surveys. Evaluate new and existing sites for National Register eligibility, so that available resources can be focused on protection and preservation of significant sites that are negatively affected.

Take account of high-altitude resources, and the impact of climate change on these resources, through survey of high-altitude areas through Section 110 or NFIM survey projects.

Continue to carry out Section 110 surveys outside of the valley bottoms where most project (Section 106) work takes place.

Establish priorities for assessing National Register eligibility of unevaluated properties in the landscape assessment area.

Heritage assessment relies upon data which covers less than 0.1 percent of the landscape assessment area, meaning that actual cultural resource distribution and significance across the landscape assessment area would be different than that defined in this report.

Recreation

Recommendations

Manage all recreational use and activities according to Federal laws and the Chugach National Forest Revised Land and Resource Management Plan. Cooperate with the State of Alaska and the National Park on developments within the watershed. Clarify boundaries and authorities. Manage National Forest System lands with an emphasis on non-motorized use during the summer season.

Facility Development – Collaborate with Kenai Fjords National Park and the State of Alaska (ADOT and DNR) to develop a non-motorized access route between the Seward Highway and Exit Glacier. Maintain and enhance the Resurrection River Trail by replacing the Martin Creek Bridge in a sustainable location and maintaining the trail as a Class III trail to Bolder Creek. Maintain the Resurrection River Trail from Bolder Creek to the Russian Lakes Trail as a Class II trail. Renovate the Resurrection River Cabin and include it in the cabins on the reservation system when the Martin Creek Bridge is replaced.

Exit Glacier Road - Manage the road in conjunction with ADOT and Kenai Fjords National Park. Manage the road as a winter multi-use trail in the winter from November to May. Assist in the development of the Exit Glacier Recreational Corridor.

Visitor Use - Develop a visitor use study to better understand public use. Include in the study the types of recreational use and where it occurs within the watershed. Monitor use to ensure that impacts to resources are avoided or minimized and assure that the recreation experience remains positive. Develop management strategies to decrease use conflicts between different user groups.

Monitoring - Monitoring all recreation use in the watershed is recommended. Maintaining a diversity of recreational opportunities and experiences in the watershed is recommended to better meet the needs of a diverse public, i.e., providing high use recreation facilities in the road corridor and low use, solitude experiences such as travel in the upper portion of the watershed.

Combined Recommendations

The following joint recommendations, data gaps and monitoring needs were identified by the group:

- Develop a cooperative monitoring program with USFS and NPS that will identify summer and winter recreation use levels. Monitor levels and areas of snow machine use (particularly in regard to mountain goat habitat) and levels and trends of bear/human interactions. The plan should identify threshold levels of interactions to trigger management action.
- Develop a joint climate change monitoring program with USFWS and NPS to monitor changes in alpine habitats and species as predicted by the USFWS model. Develop large scale habitat connectivity maps to manage for species migrations and adaptations.
- Monitor DLP numbers of brown bears and work with RCBA to increase awareness of using bear proof garbage cans through cooperative education projects. Promote the use of and availability of bear proof trash containers in the Seward area.
- Work collaboratively with NPS, ADFG, USFS, Alaska Sea Life Center, and the City of Seward to fill data gaps on salmon and salmon habitat in the watershed.
- Develop and MOU with DNR to provide collaborative assistance with USFS, NPS, RCBA to gather data (photos or vehicle license plate numbers) to enforce camping limitations on Exit Glacier Road.
- Cooperative monitoring and eradication of invasive plant species with USFS, NPS, and RCBA.
- Build a non-motorized trail along Exit Glacier Road for safety as a cooperative effort with NPS and USFS.
- Develop a study to explore stock escapement, stock abundance, and habitat and stock productivity that coho smolt outmigration enumeration studies might suggest.

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Appendix A: Cover Classes and Information for Kenai Peninsula Borough Vegetation Mapping by Marvin Rude (2007)

Earth Cover Classes

1989 Thermatic Mapping
Ducks Unlimited/Spatial Solutions, Inc.

Clear Water
Turbid Water

Snow and Ice
Barren/Sparcely Vegetated

Closed Conifer >75% conifer & 60%+ cover
Open Conifer >75% conifer & 25%-59% cover

Woodland Deciduous 10% - 24% cover
Closed Deciduous >75% decid & 60%+ cover
Open Deciduous >75% decid & 25% – 59% cover

Closed mixed – Less than 75% dominant, 60%+ cover
Open mixed – Less than 75% dominant, 25% - 59% cover

Alder - > 80% alder
Alder/Willow Riparian >60% alder or willow
Willow > 80% willow
Other Shrubs < 80% willow or alder

Herbaceous/Graminoids - < 40% shrub & < 40% Herb&grass

Clouds
Cloud Shadows

Kenai Forest Cover Classes

1997-98 Color Infrared Photos
Kenai Peninsula Bark Beetle Project

Water –	W
Barren/Snow & Ice –	Bn
White Spruce -	Ws
Black Spruce -	Bs
Sitka Spruce & Hemlock -	SH
Mountain Hemlock -	Mh
Dead Species – Precede with D	
Cottonwood	C
Aspen	A
Birch	B
Mixed – White Spruce, Hardwood	WsHd
Black Spruce, Hardwood	BsHd
Aspen & Birch	AB
Hardwood and WSpruce	HdWs
Alder	Ald
Willow	Wil
Other Shrubs	OS
Grass & Herbs	GH
Marsh	Mrsh
Nonforest – gravel pits, beach, agricultural, urban less than 10% stocked	NF
Harvest Area	Hvst
Harvest with remaining Hdwd	HvstHd

Size Class: seedling and saplings 1-5 in 1
Poles 5-9 in conifer 2
5-11 in hrdwd 2
Large 9 in + conifer 3
11 in + hrdwd 3

Stocking Percent: Woodland – 10% - 24% W
Open 25% - 59% O
Closed 60% - 100% C

Understory: Where significant and can be clearly seen on photos will be designated with a " / "
Example: DWs3O/Ws2 would be a dead overstory of large white spruce in an open stand with live white spruce unerstory.

Classification Key For Kenai Forest Cover Classes

The Alaska Vegetation Classification by L.A. Viereck, C.T. Dyrness, A.R. Batten and K.J. Wenzlick used as a guide.

I. Water---------- --------(W)

II. Nonforest (< 10% stocked) ----------(No Vegetation High Country)------ Barren/Snow/Ice (Bn)
----------(No Vegetation Low Country)---------- Nonforest (NF)

III. Forest (10% or greater stocking with trees)

A. Dead Trees----------Species, Size Class, and Stocking preceded with (D)

B. Live Trees— a.Conifer – White Spruce--(Ws) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Black Spruce-- (Bs) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Sitka Spruce/Hemlock-- (SH) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

Mountain Hemlock-(Mh) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

b. Deciduous - Cottonwood ----(C) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)
Aspen----- (A) – Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)
Birch ------(B) –Size Class Stocking
-- Large (3) - Woodland 10%-24% (W)
-- Pole (2) - Open 25% - 59% (O)
-- Seed/Sapling(1) - Closed 60% - 100% (C)

c. Mixed Stands

White Spruce and Hardwoods - (WsHd)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

Black Spruce and Hardwoods - (BsHd)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

Aspen and Birch – (AB)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

Hardwoods and White Spruce – (HdWs)

–Size Class	Stocking		
-- Large (3)	- Woodland	10%-24%	(W)
-- Pole (2)	- Open	25% - 59%	(O)
-- Seed/Sapling(1)	- Closed	60% - 100%	(C)

e. Harvested Stands----------(Hvst)

IV. Shrubs

A. Alder----------(Ald)
B. Willow----------(Wil)
C. Other Shrubs----------(OS)

V. Grasses and Herbaceous-DRY----------(GH)
VI. Marsh- WET grasses and herbaceous----------(Mrsh)

Appendix B: Migratory, Over-wintering, and Resident Bird Checklist for Resurrection River Watershed at the Seward Airport, Salt Marsh, and near Tidelands

Compiled by Carol Griswold

April 11, 2010 version 1.0

BOLD indicates species located a little farther off shore

DUCKS, GEESE AND SWANS
Greater White-fronted Goose
Snow Goose
Ross' Goose (casual)
Brant
Cackling Goose
Canada Goose

Trumpeter Swan
Tundra Swan

Gadwall
Eurasian Wigeon
American Wigeon
Mallard
Cinnamon Teal rare
Northern Shoveler
Northern Pintail
Green-winged Teal
Canvasback
Ring-necked Duck

Greater Scaup
Lesser Scaup
Harlequin Duck
Surf Scoter
White-winged Scoter
Black Scoter
Long-tailed Duck
Bufflehead

Common Goldeneye
Barrow's Goldeneye
Common Merganser
Red-breasted Merganser

GROUSE
Spruce Grouse
Willow Ptarmigan

HERONS
Great Blue Heron

HAWKS, EAGLES, AND FALCONS
Bald Eagle
Northern Harrier
Sharp-shinned Hawk
Northern Goshawk
Red-tailed (Harlan's) Hawk
Merlin
Peregrine Falcon

CRANES
Sandhill Crane

SANDPIPERS
Common Snipe
Hudsonian Godwit
Bar-tailed Godwit
Marbled Godwit
Whimbrel
Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Spotted Sandpiper
Wandering Tattler
Ruddy Turnstone
Short-billed Dowitcher
Long-billed Dowitcher
Surfbird
Semipalmated Sandpiper
Western Sandpiper
Least Sandpiper
Baird's Sandpiper
Pectoral Sandpiper
Rock Sandpiper
Dunlin
Red-necked Phalarope

PLOVERS
Pacific Golden-Plover
American Golden-Plover
Black-bellied Plover
Semipalmated Plover
Killdeer

GULLS AND TERNS
Mew Gull
Glaucous-winged Gull
Glaucous Gull
Thayer's Gull
Herring Gull
Bonaparte's Gull
Sabine's Gull possibly
Black-legged Kittiwake
Caspian Tern (possibly)
Arctic Tern

AUKS, ALCIDS
Common Murre
Pigeon Guillemot
Marbled Murrelet
Crested Auklet

LOONS
Pacific Loon
Common Loon
Yellow-billed Loon

PIGEONS AND DOVES
Rock Dove

OWLS
Great Horned Owl
Northern Hawk Owl
Northern Saw-whet Owl (possible)
Short-eared Owl

HUMMINGBIRDS
Rufous Hummingbird

KINGFISHERS
Belted Kingfisher

WOODPECKERS
Downy Woodpecker
Hairy Woodpecker (possible)

TYRANT FLYCATCHERS
Western Wood-Peewee
Alder Flycatcher

CROWS AND JAYS
Steller's Jay
Black-billed Magpie
Northwestern Crow
Common Raven

SHRIKES
Northern Shrike

WAXWINGS
Bohemian Waxwing

DIPPERS
American Dipper

THRUSHES
Varied Thrush
Gray-cheeked Thrush (possible)
Swainson's Thrush (possible)
Hermit Thrush
American Robin

NUTHATCHES
Red-breasted Nuthatch

CREEPERS
Brown Creeper

WREN
Winter Wren (possible)

SWALLOWS
Tree Swallow
Violet-green Swallow
Bank Swallow
Cliff Swallow

KINGLETS
Ruby-crowned Kinglet
Golden-crowned Kinglet

CHICKADEES
Black-capped Chickadee
Boreal Chickadee
Chestnut-backed Chickadee

LARKS
Horned Lark

PIPITS
American Pipit

SISKINS, CROSSBILLS AND ALLIES
Pine Siskin
Common Redpoll
Gray-crowned Rosy-Finch
Pine Grosbeak
Red Crossbill

NEW WORLD WARBLERS
Orange-crowned Warbler
Yellow Warbler
Yellow-rumped Warbler
Townsend's Warbler
Northern Waterthrush (possible)
Wilson's Warbler

BUNTINGS, SPARROW, ALLIES
Lapland Longspur
Snow Bunting
McKay's Bunting (possible)
Fox Sparrow
Song Sparrow
Lincoln's Sparrow
White-crowned Sparrow
White-throated Sparrow
Golden-crowned Sparrow
Dark-eyed Junco
Savannah Sparrow
American Tree Sparrow

BLACKBIRDS
Red-winged Blackbird
Rusty Blackbird

http://www.npwrc.usgs.gov/resource/birds/chekbird/r7/seward.htm