3. Affected Environment

Established in 1980 by the Alaska National Interests Lands Conservation Act (ANILCA), the Refuge was created primarily to protect the natural diversity of fish and wildlife populations and their habitats. This chapter describes the physical, biological, social, and economic components of the ecosystem that could be affected by actions associated with management of the Refuge. This chapter is divided into seven major headings: Geographic Setting, Physical Environment, Biological Environment, Human Environment, Wilderness Values, Wild River Values, and Refuge Infrastructure and Administration. Scientific name of all plants and animals are provided in appendix I.

3.1 Geographic Setting

3.1.1 Land Status

Two acts of Congress, the Alaska Native Claims Settlement Act of 1971 (ANCSA) and the Alaska National Interest Lands Conservation Act of 1980 (ANILCA), determined the current land ownership patterns of the Refuge. ANCSA authorized the formation of village and regional Native corporations and enabled them to select and gain title to large blocks of federal land. ANILCA established the Refuge.

Refuge boundaries were drawn roughly along or near major ecological features, such as rivers or watershed boundaries, regardless of existing land ownership patterns. Consequently, the refuge boundaries incorporated lands that are owned or selected by individuals, Native corporations, or the state of Alaska (Figure 3-1, Figure 3-2, and Figure 3-3; Table 3-1).

The exterior boundary of the Koyukuk encompasses approximately 4,519,952 acres. The State owns 21,662 acres. Regional and village native corporations own 412,850 acres. Private property including 130 Native allotments total 15,725 acres. The remaining 4,069,715 acres of land are administered by the refuge (Table 3-2).

The exterior boundary of the Northern Unit Innoko encompasses approximately 750,991 acres. The State owns 37,839 acres. Regional and village native corporations own 285,045 acres. Private property including 25 Native allotments total 6,206 acres. The remaining 421,901 acres of land are administered by the refuge (Table 3-3).

The exterior boundary of the Nowitna Refuge encompasses approximately 2,058,057 acres. Regional and village Native corporations own 154,644 acres. Private property including 25 Native allotments total 2,052 acres. The remaining 1,901,361 acres of land are administered by the refuge (Table 3-4).

Table 3-1. Surface land status of the Refuge, as of May 2008.

Land Status	Koyukuk		Northern Unit Innoko		Nowitna	
USFWS	3,830,724		387,109		1,826,645	
	Selected	Conveyed	Selected	Conveyed	Selected	Conveyed
State of Alaska	21,415	21,662	18,968	37,839	73,457	0
Regional Native Corporation	204,025	375,628	8,521	241,198	0	140,013
Gana-A'Yoo Limited	11,720	37,222	5,997	43,847	0	0
Zho-Tse Incorporated	0	0	853	0	0	0
Dineega Corporation	0	0	0	0	0	14,631
Native Allotment (number)	1831 (15)	15,713 (115)	453 (3)	62066 (49)	1259 (9)	2048 (16)
Other Private	0	12	0	0	0	4

Table 3-2. Surface land status[a] of the Koyukuk, as of June 2008.

Category	Landowner	Area in Acres[b]		
		Conveyed[c]	Selected	Total
Federal – Refuge	United States	3,830,724	0	3,830,724
State Government	State of Alaska	21,662	21,415	43,077
Native Allotments	Many (130 landowners)	15,713	1,831	17,544
Regional Native Corporation	Doyon Ltd.	375,628	204,025	579,653
Other Private		12	0	12
Village Native Corporation	Gana-a'Yoo Limited	37,222	11,720	48,942

Table 3-3. Surface land status[a] of the Nowitna, as of June 2008.

Category	Landowner	Area in Acres[b]		
		Conveyed[c]	Selected	Total
Federal – Refuge	United States	1,826,645	0	1,826,645
State Government	State of Alaska	0	73,457	73,457
Native Allotments	Many (25 landowners)	2,048	1,259	3,307
Regional Native Corporation	Doyon Ltd.	140,013	0	140,013
Other Private		4	0	4
Village Native Corporation	Dineega Corporation	14,631	0	14,631

Table 3-4. Surface land status[a] of the Northern Unit Innoko, as of June 2008.

Category	Landowner	Area in Acres[b]		
		Conveyed[c]	Selected	Total
Federal – Refuge	United States	387,109	0	387,109
State Government	State of Alaska	37,839	18,968	56,807
Native Allotments	Many (52 landowners)	6,206	453	6,659
Regional Native Corporation	Doyon Ltd.	241,198	8,521	249,719
Other Private		0	0	0
Village Native Corporation	Gana-a'Yoo Limited	43,847	5,997	49,844
	Zho-Tse Corporation	0	853	853

[a]*Acreage figures do not include submerged beds of meandering water bodies (rivers of 198 feet or more in width and lakes of 50 acres or more). Ownership of the submerged lands beneath these water bodies depends on the navigability status and is yet to be determined for many of the water bodies. No ownership of the land beneath these water bodies is implied in this table.*

[b]*All acreages are GIS-calculated approximations and may differ from official acreage figures reported elsewhere. All data are from Master Title Plats maintained by the Bureau of Land Management.*

[c]*Includes patented and Interim Conveyed (IC) lands. Only land claims within the Refuge boundary are reported.*

3.1.1.1 Village Native Corporation Land

Three village Native corporations, Gana-A'Yoo Limited, Zho-Tse Corporation, and Dineega Corporation, have land holdings within the refuge boundaries. Each corporation has a total land entitlement of 121,507 acres, and each has taken some of this entitlement outside the refuge boundary as well as within. As of May 2008, about 37,222 in the Koyukuk and 43,847 acres in the Northern Unit Innoko had been conveyed to Gana-A'Yoo Limited, and an additional 11,720 acres in the Koyukuk and 5,997 acres in the Northern Unit Innoko had been selected. Zho-Tse Corporation has selected 853 acres inside the Northern Unit Innoko. The Dineega Corporation owns 14,631 acres in the Nowitna. Land status within the Refuge will change as selected lands are conveyed, relinquished, or rejected. However, land status should be resolved by 2009 under the provisions of the Alaska Land Transfer Acceleration Act of 2004 (P.L. 108-452).

3.1.1.2 Regional Native Corporation Lands

Doyon Limited (Doyon) holds title to 375,628 acres of land in the Koyukuk; 241,198 acres in the Northern Unit Innoko; and 140,013 acres of land in the Nowitna; and has selected an additional 204,025 acres within the Koyukuk and 8,521 acres within the Northern Unit Innoko (Table 3-1, Table 3-2, Table 3-3).

According to the conveyance rules of ANCSA section 14(f), Doyon is granted the subsurface rights to the lands conveyed to both Zho-Tse and Dineega village corporations. This provision gives the regional corporation the rights to potentially valuable mineral interests but gives the village control of the surface lands necessary to supply its subsistence and economic needs.

3.1.1.3 Native Allotments

Until its repeal in 1971, the Native Allotment Act of 1906 authorized Alaskan Natives to claim up to 160 acres of land. In addition, a 1998 amendment to ANCSA (section 432 of P.L. 105-276

[43 U.S.C. 1629g]) authorized qualified Alaskan Native Vietnam veterans to apply for an allotment if they had not previously done so. The 1998 law addressed the concern that military service may have prevented some Native veterans from applying for an allotment under the 1906 Act. The application period for these new allotments closed on January 31, 2002. To date, a total of 115, 49, and 16 allottees in the Koyukuk, Northern Unit Innoko, and Nowitna, respectively, have been deeded a total of 15,713, 6,206, and 2,048 acres within the Koyukuk, Northern Unit Innoko, and Nowitna, respectively, (Table 3-1, Table 3-2, Table 3-3, and Table 3-4).Another 1,831 acres (15 parcels), 453 acres (3 parcels), and 1,259 acres (9 parcels) in the Koyukuk, Northern Unit Innoko, and Nowitna, respectively, are selected, including a total of 207 Vietnam veteran allotment claims.

3.1.1.4 Other Private Lands

Congress extended the nation's principal land laws to Alaska in 1884. Many of these laws were designed to encourage private settlement and improvement of public lands. There is only one private patent within the boundaries of the Refuge. This patent was issued for a trade and manufacturing site, totaling about 12 acres. The Trade and Manufacturing Act of 1898 allowed cash entry for up to 80 acres of land to be used as a place of business.

3.1.1.5 State of Alaska

The State of Alaska owns 21,662 and 37,839 acres in the Koyukuk and Northern Unit Innoko, respectively (Table 3-1). There are no state lands within the Nowitna. The Alaska Statehood Act (PL 85-508) entitled the state to select 102,550,000 acres of vacant, unappropriated, and unreserved land under the general grant, and to select an additional 400,000 acres to promote development and expansion of communities. The State was also granted title to most of the existing roads, airfields, and associated facilities under the Alaska Omnibus Act (Public Law 86-70).

3.1.1.6 Submerged Lands

In general, the lands beneath tidelands and inland navigable waters were granted to the state of Alaska by the Equal Footing Doctrine, the Submerged Lands Act of 1953, and the Statehood Act of 1958. However, lands beneath water bodies that were reserved or withdrawn by the federal government prior to statehood on January 3, 1959, may have been retained by the United States. If the U.S. did not reserve or withdraw submerged lands, then the ownership of submerged lands is determined on the basis of navigability. If a water body is navigable, the underlying bed of the river or lake belongs to the State; if non-navigable, the bed belongs to the adjacent landowner(s).

Undoubtedly, the Refuge contains both navigable and non-navigable waters. However, the status of many water bodies has not yet been determined. Any disagreements between the State and the federal government over what waters are navigable or non-navigable are generally resolved through the federal courts.

Figure 3-1
Koyukuk land status, existing easements, and rights of way

Land Status

Selected		Conveyed
	Other Private	
	Regional Native Corp.	
	Village Native Corp.	
	State of Alaska	

Other Features

- Refuge Boundary
- Refuge Land
- Designated Wilderness
- RS-2477
- 17(b) Trails
- 17(b) Sites

Miles
0 5 10 20
0 5 10 20
Kilometers

19-0005

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: May 13, 2008

160°0'0"W 159°0'0"W 158°0'0"W 157°0'0"W 156°0'0"W 155°0'0"W 154°0'0"W
N.0.0.99
65°0'0"N

RST 1913
RST 1893
Hughes
RST 308
Nogahabara Sand Dunes
Huslia
14 C3 C4 C9 D9
12a C4
14a C4
12 D9
Koyukuk NWR
8 C3 C5 D1
10 C5
Koyukuk
RST 287
RST 287
RST 1846
Yukon River
Ruby

Figure 3-2
N. Innoko land status, existing easements, and rights of way

159°0'0"W 158°0'0"W 157°0'0"W

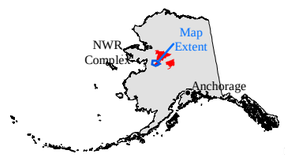
Land Status

Selected		Conveyed
	Other Private	
	Regional Native Corp.	
	Village Native Corp.	
	State of Alaska	

Other Features

- Refuge Boundary
- Refuge Land
- RS-2477
- 17(b) Trails
- 17(b) Sites

Miles
0 2.5 5 10
0 2.5 5 10
Kilometers



N

19-0003

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: May 13, 2008

Koyukuk
Nulato
Kaltag
Galena
Yukon River
RST 287
RST 161
RST 299
RST 255
RST 63
RST 245
14 C6
20 C5
1a L
Northern Innoko NWR (Kaiyuh)

159°0'0"W 158°0'0"W 157°0'0"W

Figure 3-3
Nowitna land status and rights of way

Land Status

Selected		Conveyed
	Other Private	
None	Regional Native Corp.	
None	Village Native Corp.	
	State of Alaska	None

Other Features

- Refuge Boundary
- Refuge Land
- RS-2477

Miles
0 5 10 20
0 5 10 20
Kilometers

N

19-0004

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: May 13, 2008

156°0'0"W 155°0'0"W 154°0'0"W 153°0'0"W

65°0'0"N

64°0'0"N

Yukon River

Nowitna NWR

Ruby

Tanana

Poorman

RST 287
RST 1846
RST 340
RST 15
RST 19
RST 13
RST 129
RST 758
RST 1714
RST 345

Although judicial action through the Quiet Title Act has been the primary means of clearing title to submerged lands, recent Bureau of Land Management regulation changes regarding Recordable Disclaimers of Interest in Lands (RDI) provide an administrative means to clear title to submerged lands. The RDI process allows the Secretary of Interior, acting through the BLM, to disclaim land interests that have terminated or are invalid. In February 2003, the State filed its first Disclaimer application for submerged lands beneath the Black River in northeast Alaska. An RDI for the Black River was issued later that year. The State has filed numerous subsequent applications and cleared title to large areas of lands, but none have been for submerged lands within the Refuge.

Adjudicating the extent and boundaries of navigable waterways may take many years to resolve. In the meantime, the Service is cooperating with the State on a case-by-case basis regarding management of major waterways that may be determined navigable.

3.1.1.7 17(b) Easements

Section 17(b) of ANCSA requires the federal government to reserve easements for access to public lands or waters whenever land is conveyed to Native corporations. Easements are reserved to ensure access to public lands and waters that would otherwise be completely blocked by conveyed Native corporation lands. Easements can be linear (i.e., roads and trails), or one-acre sites for use as temporary campsites and/or to change modes of transportation. Each 17(b) easement reserves a right to use land owned by another for a specified purpose. Public activities, such as recreation and hunting, are not authorized on the easement or on the private lands surrounding the easement or through which the easement passes. The conveyance document describes in detail each 17(b) easement and the specific use(s) reserved by that easement. See appendix G for a complete list of trails and easements listed with the State.

3.1.1.8 RS 2477 Rights-of-Way

The state of Alaska identifies numerous claims to roads, trails, and paths across federal lands under Revised Statute 2477 (RS 2477), a section in the Mining Act of 1866 that states, "The right-of-way for the construction of highways over public lands, not reserved for public uses, is hereby granted." RS 2477 was repealed by the Federal Land Policy and Management Act of 1976, subject to valid existing claims.

Assertion and identification of potential rights-of-way does not establish the validity of these claims nor the public's right to use them. The validity of all RS 2477 rights-of-way will be determined on a case-by-case basis, either through the courts or by other legally binding document. The state of Alaska has identified in Alaska Statute 19.30.400 three routes on the Refuge it claims may be asserted as rights-of-way under RS 2477 (see appendix F): RST #1888 – Hogatsa Road (Koyukuk), RST #840 – Palisades Portage Trail (Nowitna), and RST #161 (also known as DOT 97-152) – Nulato-Dishkaket Trail (Northern Unit Innoko). The three trails total 137 miles in length, but not all of the trails are entirely located on refuge land.

3.1.2 Ecosystems

An ecosystem approach to refuge management was initiated by the 1997 National Wildlife Refuge System Improvement Act. This management strategy acknowledges that living organisms, their physical surroundings, and the natural cycles that sustain them are all interconnected. Ecosystems are not limited by land ownership or conservation unit boundaries. From this perspective, the ecosystem level is an appropriate level for refuge planning. Hence, refuge lands are to be managed in the context of, and in concert with,

surrounding public and private lands. Most Alaskan ecosystems are intact, and refuge management should contribute to maintaining the health of these natural systems.

The U.S. Fish and Wildlife Service ecosystem map defines 10 ecosystems in Alaska (USFWS 1996). The source for this map was the U. S. Geological Survey's Hydrologic Unit Map based upon the delineation of watersheds. The Service then grouped these watersheds based on vegetation cover types, physiography, and optimum size. The Refuge is located within the western portion of the Service's Interior Alaska Ecosystem (Figure 3-4).

The Interior Alaska Ecosystem is an inter-montane plateau bounded by the Alaska Range on the south and east and by the Brooks Range on the north. It extends west to the Nulato hills, and encompasses approximately 528,000 square miles (Van Cleve et al. 1983). This vast region is characterized by small, isolated mountain ranges, large areas of gently sloping uplands, meandering rivers with broad floodplains, and extensive, flat lowlands dotted with numerous thaw lakes. Discontinuous permafrost underlies as much as 75–90 percent of the terrain, but can be absent from south facing slopes and major floodplains. Black spruce forest is the dominant vegetation type below tree line and is closely associated with the presence of permafrost. Sites with warmer soils sustain white spruce and deciduous communities. Above tree line, subalpine shrubs, tundra sedge meadows, and heaths predominate. The major river systems draining interior Alaska are the Yukon River and its largest tributary, the Tanana River.

Other refuges and federal lands included in this ecosystem are: Tetlin, Yukon Flats, Kanuti, and Innoko refuges; Denali National Park and Preserve; Yukon-Charley Rivers National Preserve; the Steese National Conservation Area; and the White Mountains National Recreation Area.

There have been numerous attempts to classify ecosystems and ecoregions in Alaska (for example, Gallant et al. 1995, Nowacki and Brock 1995). These classification systems are similar and vary mainly in small scale boundary differences and terminology. To aid Alaskan users and facilitate interagency work, Nowacki et al. (2001) attempted to unify ecoregion boundaries. The resulting map delineates 32 ecoregions in Alaska. Of these, the Yukon River Lowlands Ecoregion predominates on the Koyukuk and Northern Unit Innoko, and covers the northern half of the Nowitna (Figure 3-4). This ecosystem is characterized by floodplains lined by deep deposits of undifferentiated sediments, and a continental climate with cool, moist summers and cold, dry winters. Permafrost, present in older floodplains and adjacent lowlands, produces poor drainage, a prevalence of wet, organic rich soils, and a dense concentration of lakes and ponds. Permafrost dominated lowlands are characterized by black spruce woodlands, and birch-ericaceous shrub and sedge tussock bogs. Permafrost is absent in younger floodplains and well drained soils. The vegetation along the major rivers is dominated by white spruce and balsam poplar, while floodplains and river bars support tall stands of alders and willows. Wet sedge meadows are common around sloughs, oxbow lakes, and the numerous ponds formed by permafrost thaw.

Foothills and mountainous areas along the peripheries of the Refuge are classified in four other ecoregions (Figure 3-4): the Kobuk Ridges and Valleys Ecoregion, forming the northern boundary of the Koyukuk; the Ray Mountains Ecoregion, found along the southeastern edge of the Koyukuk and just north of the Northern Unit Innoko; the Kuskokwim Mountain Ecoregion, covering the southern portion of the Nowitna and the southeast edge of the Northern Unit Innoko; and the Nulato Hills Ecoregion which lies northwest of the Northern Unit Innoko and along the western boundary of the Koyukuk.

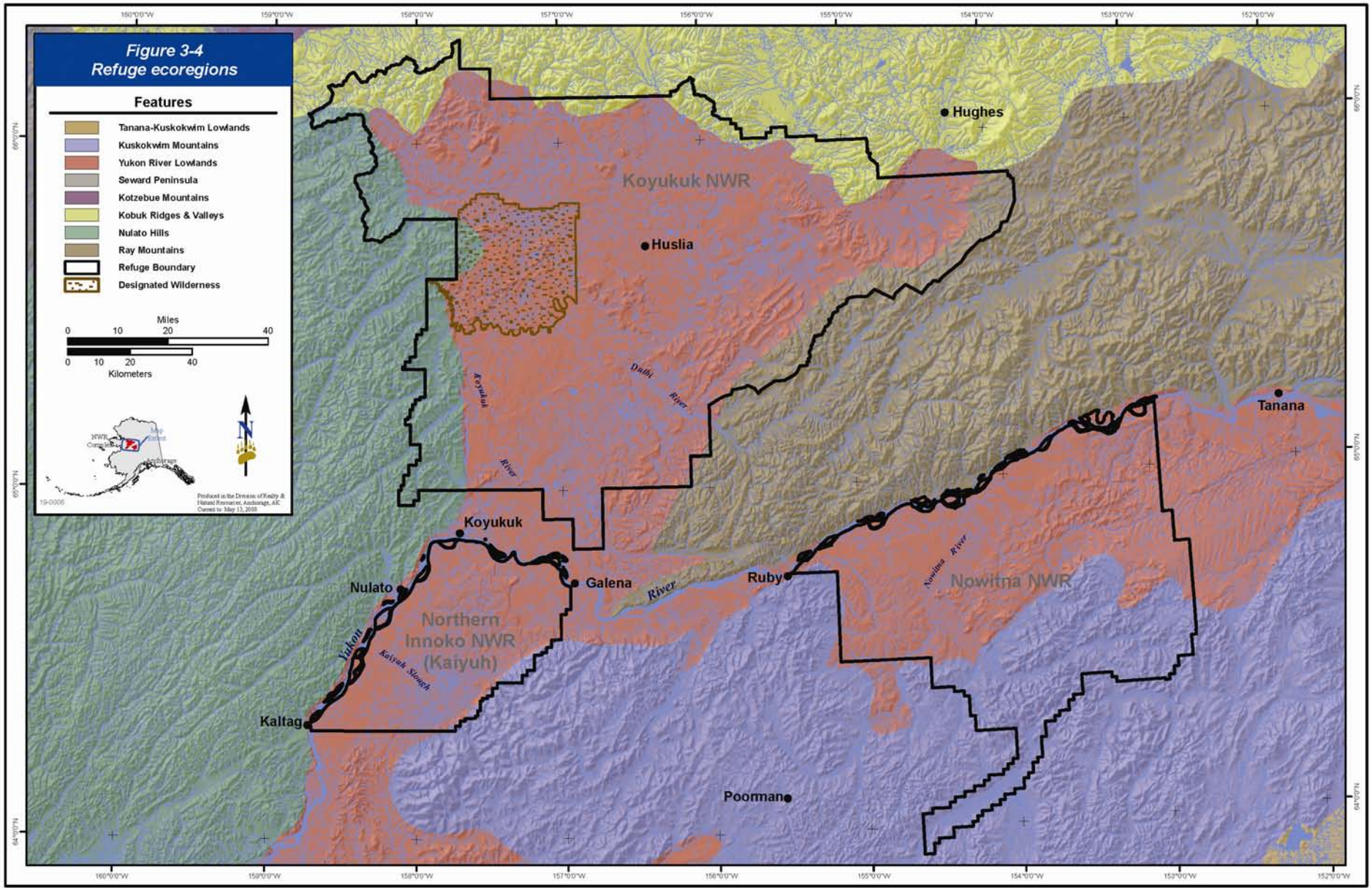


Figure 3-4. Refuge ecoregions

All of those ranges are typified by low, rolling hills and mountains, with a generally continental climate that is cooler than the lowlands. Thin to moderately thick permafrost underlies most of these areas, although is it discontinuous in the Ray Mountains Ecoregion. Vegetation patterns are strongly influenced by elevation, with shrub-birch and lichen tundra on the highest mountains and ridges. Further down slope occur willow, birch, and alder shrub lands which give way to spruce and birch woodlands at progressively lower elevations. Black spruce forests dominate on north facing slopes and in moist valleys, while white spruce and deciduous forests are found on south facing slopes and in floodplains.

3.2 Physical Environment

3.2.1 Climate

The Refuge region has a continental subarctic climate which is characterized by low annual precipitation, low humidity, low cloudiness, and large diurnal and annual temperature ranges. The summer sun provides almost continuous radiation and heats valleys, which are protected from coastal winds and clouds by surrounding hills. On June 21, the area gets nearly 22 hours of daylight. Between mid-May and late-July, there are 72 consecutive days in which the sun remains continuously above the civil twilight limit. During the summer months (June–August), temperatures are generally mild, with a mixture of warm sunny days and cooler rainy days. The average summer daily high temperature at Galena (1942–2007) is 66 degrees Fahrenheit with highs above 80 degrees Fahrenheit occurring in most years (see Table 3-5). Summer daily low temperatures average 58 degrees Fahrenheit, and frosts may occur in any month. Galena experiences an average 140 frost-free days, and the growing season generally ranges from 90–130 days.

Galena receives an average of 13.3 inches of measurable precipitation. Most occurs as rainfall during July–September (45 percent). The fall season is fairly short, with snowfall beginning in late September or early October. Ice is present in the lakes and many sloughs from early October to late May. Freeze-up of the Yukon River generally occurs in late October or early November. Winter snowfall (November–March; average of 66 inches) accounts for nearly 30 percent of annual precipitation. Maximum snowpack at Galena averages 26 inches and occurs in March. Eleven snow markers were installed on the Refuge in 2004–2006, providing both an east-west and north-south gradient of snow depth across the refuge units. Snow depths are observed aerially at the start of each month from December through May. From February through April, snow depths range from two to three feet, with lesser snowpack in other winter months.

During the short days of winter, temperatures are primarily influenced by weather patterns rather than solar radiance. On December 21, the sun stays above the horizon for less than four hours. Cold spells (usually 20–40 degrees below zero but sometimes as cold as 60–70 below zero), caused by high pressure systems with clear skies and no wind, are moderated by intervening milder weather (20 degrees below zero to 20 degrees above zero), with clouds, snow, and light to moderate winds (low pressure systems). Local valleys become cold sinks, and temperatures are among the coldest on the continent.

April and May are transitional months as daylight and temperatures increase, and snow and ice melt. Most waterfowl arrive in late April to early May as ground cover and open water emerge. Breakup of the Yukon River ice occurs in mid-May, with green up of trees and shrubs in late May.

Table 3-5. Climate data for Galena, Alaska 1942–2007. (Data available from National Climate Data Center, NOAA).

Average:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max. Temperature (°F)	-2	5	17	33	54	67	69	62	51	30	11	0	33
Median Temperature (°F)	-10	-4	5	23	45	58	60	55	44	24	4	-7	25
Min. Temperature (°F)	-18	-13	-6	13	35	48	52	47	36	18	-2	-15	16
Total Precipitation (in.)	0.69	0.76	0.66	0.49	0.61	1.27	1.92	2.47	1.58	0.98	0.81	0.89	13.14
Total Snowfall (in.)	9.35	10.04	8.50	5.08	0.42	0	0	0	0.63	8.52	11.29	12.46	66.29
Max. Snow Depth (in.)	20	24	26	21	4	0	0	0	0	5	11	17	26

3.2.2 Landforms

3.2.2.1 Koyukuk and Northern Unit Innoko

The topography of the Koyukuk and Northern Unit Innoko is dominated by the Koyukuk Flats. This extensive lowland, covering about 4,000 square miles, lies along the Koyukuk River from the Indian River Upland near Hughes to where the Yukon River narrows between the Kaiyuh Mountains and the Nulato Hills below Kaltag. Nearly all the Koyukuk River portion is included in Koyukuk, while the Yukon River portion forms the Kaiyuh Flats.

On the Koyukuk, the Koyukuk Flats encompasses the broad Koyukuk River floodplain, adjacent sand dune sheets, and broad silt terraces. Elevations in the flats are about 300 feet where the Koyukuk enters the Refuge near Huggins Island and only100 feet above sea level where the Koyukuk River leaves the Refuge near its confluence with the Yukon River. The floodplain is 5–20 miles wide, with meander belts in younger units along the rivers and thaw lakes in older units. Broad, rolling silt plains—mantled in part by dunes and in part pocked by thaw lakes—stand 100 to 200 feet above the central plains and merge imperceptibly with the surrounding uplands. Several low bedrock hills rise from the center of the lowlands. Smaller rivers and streams meander across the lowland and have numerous side sloughs.

Northeast of the Koyukuk Flats is an area of low, gently rounded ridges with summits of 1,500 to 2,000 feet interspersed with irregular lowlands and broad, flat divides. This area is known as the Indian River Uplands. Ridges forming the eastern boundary of the Koyukuk are generally parallel and trend northeastward, with a few peaks rising to over 3,000 feet. The streams and small rivers that drain these uplands have extremely irregular courses. Numerous thaw lakes are present in the lowlands, valleys, and broad passes.

North of the Koyukuk Flats lies the Pah River section of the Western Alaska province. Here a diversified topography includes compact groups of hills and low mountains (including the Purcell Mountains and Zane Hills) 20 to 40 miles long with elevations up to 4,000 feet, surrounded by rolling plateaus 500 to 1,500 feet high and broad lowland flats 5–10 miles across. The hills were glaciated, as shown by crested divides and flared valleys in highest parts north of the Koyukuk. In lower areas, the down slope movement of rock and soil has nearly obliterated glacial effects. The northern and western parts of the Pah River section drain to the Selawik and Kobuk rivers, while the southern and eastern parts drain via the Huslia and Hogatza rivers to the Koyukuk River. Numerous thaw lakes and sluggishly meandering streams lie in the lowland flats.

To the west of the Koyukuk Flats (west of the Yukon and Koyukuk rivers) are the Nulato Hills. The topography here is dominated by northeast trending ridges 1,000 to 2,000 feet high with rounded summits and gentle slopes. Three highland areas of steeper ridges rise to near 4,000 feet. Streams on the east side flow to the Yukon River either directly or via the Koyukuk River. Major streams are markedly parallel, flowing northeast along fault zones.

The majority of the Northern Unit Innoko consists of the Yukon River portion of the Koyukuk Flats. To the south and east are the Kaiyuh Mountains, a range of northeast-trending ridges with rounded to flat summits 1,500 to 2,000 feet high and broad gentle slopes. Higher peaks occur infrequently. The Kaiyuh Mountains are the western extension of the Kuskokwim Mountains.

3.2.2.2 Nowitna

The northern part of the Nowitna includes part of the Nowitna Lowland. Wetlands predominate in this area, with numerous lakes and marshlands along the northern boundary. Elevations of less than 200 feet can be found along the Yukon River on the Refuge's northern boundary. The southern part of the refuge is characterized by foothills on the northern edge of the Kuskokwim Mountains. The foothills in the southeast corner of the Refuge rise to over 2,300 feet. The northern lowlands and southern foothills are bisected from the center of the Refuge to the eastern boundary by a band of vegetated sand dunes and bedrock hills.

Almost all of the Refuge is in the Nowitna River watershed. The Nowitna River runs the entire length of the Refuge from south to north before emptying into the Yukon, and forms a wide meandering floodplain varying in width from one to six miles. The river corridor narrows in the Nowitna Canyon portion, as the river flows through hills in the south central portion of the Refuge. The Big Mud River and Grand Creek flow through the Kuskokwim Mountain foothills on the east side of the Refuge and join before flowing into the Nowitna River. The Little Mud River drains the northern edge of the foothills, the central wetlands and the vegetated dune areas.

3.2.3 Geology

The Koyukuk, Northern Unit Innoko, and Nowitna lie within the vast floodplains of the Yukon and Koyukuk rivers, part of the plains and plateau region of interior Alaska (Mark Anthony and Tunley 1976). The broad river valleys are edged by small mountain ranges of low relief, and there are no steep, rugged mountains or glaciers. The region is an extension of the central plateau system found in British Columbia, the Yukon Territory, and the Western United States. It extends westward to the Bering Sea. The Yukon-Koyukuk basin itself is volcanic in origin, with perimeters formed of metamorphosed continental rock. The Brooks Range to the north, the Ruby Uplift (including the Kaiyuh Mountains, the Kokrines Hills, and the Hodazna Highlands) on the east, and the base of the Seward Peninsula to the west delineate the basin. Farther south, the perimeter of the basin is unknown, probably buried under the Yukon-Kuskokwim delta.

In terms of plate tectonics, the Yukon-Koyukuk Basin is believed to be a drifted piece of oceanic crust that collided with the continental crust of the southern Brooks Range and the Ruby Uplift. Upon collision, the oceanic crust overrode the continental material. Thus, the continental Brooks Range and Ruby Uplift borderlands were the leading edge of a subduction zone, while the oceanic crust was thrust up, over, and through the borderlands. Further thrusting occurred inside the formation itself, bringing volcanic rocks over ocean crust. The result is a basin rim of overlapping stacks: fine grained volcanic rock over dark colored

igneous rock over metamorphic rocks. Troughs formed on the north and northeast fringes of the basin were filled with conglomerate material.

Very little bedrock is exposed in the refuge area; most is covered by wind and water deposited silt, sand, and gravel, much of which is glacial in origin. The most recent Ice Age (Wisconsonian) had three glacial periods, interspersed with warmer interglacial periods. The last glacial period peaked about 20,000 years ago and ended about 10,000 years ago. During this time, when great masses of ice covered much of North America, very little glacial ice was found in the Yukon-Koyukuk region. Rivers in the area follow varying courses. A large Pleistocene lake formed over the Nowitna Lowland, and beach gravels from the lake edge can still be found in the Ruby and Long Creek areas. This lake deposited deep layers of silt (up to 1,400 feet) over much of the Nowitna. Silt eroded by rivers and streams in the eastern portion of the Nowitna formed the geologically unusual Boney Creek Dissected Benchlands. The silt layer tapers off along the bedrock ridges of the uplands.

Glacial silts, sand, and till, deposited by wind and water, also cover much of the underlying bedrock on the Koyukuk. Glacial drift present in the upper valleys of Billy Hawk and Huslia rivers is older than 100,000 years old and probably came from glaciers in the Purcell Mountains and the Zane Hills. Local glaciation probably did not extend beyond the Huslia River. At one point, wind-blown glacial flour (loess) covered much of the Refuge, but was re-worked by streams and rivers in many areas. Two loess terraces are present; the higher (and oldest) is 100–200 feet above rivers, and the lower (younger) terrace is only 30–80 feet above rivers. Between these terraces, and on the Koyukuk River floodplain, are broad areas of wind-blown sand. The resulting sand dunes are mainly stabilized, or partially stabilized, by vegetation. The Nogabahara Sand Dunes are an active portion of this extensive dune system.

The volcanic bedrock of the Kaiyuh Flats is primarily overlain by micaceous silts (Patton and Moll-Stalcup 2000). The youngest deposits lie in the Yukon River floodplain. Older floodplain silt deposits (some dating from the Pleistocene) are found in the southern, northwestern, and eastern portions of the Northern Unit Innoko. The oldest silt deposits (also Pleistocene) form a central, higher terrace rising 10 to 100 meters above the floodplain that is dotted by many small thermokarst lakes. There is little exposure of the volcanic bedrock on the Refuge, with the exception of the outcrop that forms Pilot Mountain. This same material forms Koyukuk Mountain, just north of the Refuge. The Kaiyuh Flats are at the edge of the Yukon-Koyukuk basin, which is bounded by the Kaiyuh Hills (a portion of the Ruby Uplift) on the southeast border of the Refuge. Running along the base of the Kaiyuh Hills is the Kaltag fault line, which crosses the southern portion of the Refuge from northeast to southwest. The fault line is visible from the air in forested areas along the base of the hills. West of Bonanza Creek, the fault follows a more westerly course away from the mountains and across the flats. This fault line extends eastward into the northern Yukon Territory, Canada (Lane 1992). There has been limited seismic activity related to the fault, including a magnitude 6.0 earthquake near Ruby in February 2000 (City of Galena 2007).

3.2.4 Soils and Permafrost

Soil units mapped at a scale of 1:500,000 are described in the Exploratory Soil Survey of Alaska (Rieger et al. 1979). These soil units, called associations, are collections of individual soils grouped by landscape position and texture. Soil associations and locations are shown in Figures 3-5a, 3-5b, and 3-5c.

Soil associations found on the Refuge are fairly uniform, with poorly drained silt loams dominating. These soils are continually wet and are generally underlain by continuous

permafrost except near large water bodies, where permafrost is discontinuous. Combined with peat, these soils are found on over 80 percent of the Refuge, including much of the lowlands areas of the Koyukuk, Nowitna, and Kaiyuh Flats. These soils vary from sandy and clayey in some areas to very gravelly on slopes and in valleys at higher elevations.

Permafrost is ground that is continuously frozen through at least two successive cold seasons and the intervening summer. Permafrost is found throughout the area except along major drainages and is usually shallow (from 10 to 25 inches). The western interior region of Alaska is primarily discontinuous permafrost (50–90 percent), containing medium amounts of ground ice with a thick overburden layer, while some areas are underlain by continuous permafrost, with medium amounts of ground ice and thick overburden. In interior Alaska, temperatures of the upper layers of the permafrost are in the range of 28 to 31 degrees Fahrenheit.

3.2.5 Minerals

3.2.5.1 Nowitna

Indications of mineral presence in the region are shown in Figure 3-6. Except for one underground effort at Gold Hill, all mined deposits were placers. Most were first explored in the early 1900s, and have been mined intermittently for about 75 years. Metal produced was gold, plus some tin. Latest known major exploration in the region was by Anaconda for hard rock deposits in the Long-Poorman area.

Mining claim records show that most placers have had recent activity. There are no mining claims on the Refuge. Four claims, staked on the Refuge in 1979, on California Creek in section 17, T. 13 S., R. 27 E., were abandoned in 1986 and voided by the Bureau of Land Management in 1987. U.S. Bureau of Mines records credit the property with past production (amount unspecified). There are also claims further up California Creek that are not on the Refuge.

In the Long-Poorman area, placer mines are located on nearly all the tributaries of the Sulatna River, which drains to the Nowitna Lowland. Although gold was found on nearly all the streams in the area, production was short-lived. The placers were commonly irregular and discontinuous, and pay streaks were spotty and disseminated. Many were therefore believed to be of beach origin (Mertie and Harrington 1924).

Although spotty, the widespread nature of the gold indicates that large placers do exist. The main problem with prospecting in the Nowitna region seems to be that areas where large placers are expected are buried by silt. "No doubt there are large buried placer deposits in the broad depressions that are now filled with deep alluvial deposits—one can see such extending up the larger valleys well towards their heads. But since the present streams generally do not follow exactly in the courses of the original streams, any prospecting results are bound to be erratic and prospecting is not justified. (Eakin 1918).

159°0'0"W
158°0'0"W
157°0'0"W
156°0'0"W
155°0'0"W
154°0'0"W
65°0'0"N

Hughes
Huslia
Koyukuk NWR
Koyukuk
Ruby
Yukon River

Figure 3-5a
Koyukuk Soil Associations

Features

- Cold, loamy floodplain; wet to well-drained
- Cold, loamy to very gravelly lowland; wet to well-drained
- Cold, sandy to loamy to very gravelly upland; well-drained to poorly-drained
- Cold, very gravelly upland; well-drained
- Active sand dunes
- Refuge Boundary

Miles
0 5 10 20
0 5 10 20
Kilometers

N

19-0024

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: Aug. 5, 2008

Figure 3-5b
N. Innoko Soil Associations

Features

- Cold, loamy floodplain; wet to well-drained
- Cold, loamy to very gravelly lowland; wet to well-drained
- Cold, very gravelly upland; well-drained
- Refuge Boundary

Miles
0 2.5 5 10
0 2.5 5 10
Kilometers

19-0023

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: Aug. 5, 2008

159°0'0"W
158°0'0"W
157°0'0"W

Koyukuk

Yukon River

Nulato

Galena

Northern Innoko NWR (Kaiyuh)

Yukon

Kaltag

159°0'0"W
158°0'0"W
157°0'0"W

Figure 3-5c
Nowitna Soil Associations

Features

- Cold, loamy floodplain; wet to well-drained
- Cold, loamy to very gravelly lowland; wet to well-drained
- Cold, sandy to loamy to very gravelly upland; well-drained to poorly-drained
- Cold, very gravelly upland; well-drained
- Refuge Boundary

Miles
0 5 10 20
0 5 10 20
Kilometers

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: Aug. 5, 2008

19-0022

156°0'0"W
155°0'0"W
154°0'0"W
153°0'0"W
65°0'0"N
64°0'0"N
Yukon River
Ruby
Tanana
Nowitna NWR
Poorman

Another indication of mineral resources is the Refuge's location at the intersection of three regional belts of tin-tantalum-niobium mineralization (Warner 1985). The Kokrines-Hodzana belt trends southwest from the Sithylemenkat Lake area to the Tozimoran Creek area, and across the north part of the Refuge to the Long-Poorman area. The Yukon-Tanana belt extends west from Circle through the Tofty tin district to upper Cosna River east of the Refuge. South of the Refuge, the Kuskokwim belt is located southwest from near Mystery Mountain. The belts are established from evidence of favorable country rock (biotite granite) and from compounds of tin, tantalum, and niobium found mostly in gold placer concentrates.

Coal beds exposed in the Refuge at the Palisades are approximately 20 feet thick, and are inter-bedded with lowland silt believed to be no older than late Pliocene (1–10 million years ago). Consequently, the coal is probably very immature. Thin or poor quality coal is known from limited exposures along the Yukon River and in prospect shafts. The existence of a Tertiary basin, which might contain better, older, and deeper coal, is doubtful.

An active geothermal basin may underlie the northcentral portion of the Refuge; however, there are no known geothermal resources on the Refuge.

3.2.5.2 Koyukuk and Northern Unit Innoko

Though some tentative estimates of mineral potential in the region can be made, there is a lack of extensive geologic mapping, sampling, and drilling that an accurate assessment requires. Until more exploration is undertaken, discussion of mineral resources will be based on the limited information that is available.

Sites of known or indicated mineralization, and locations of favorable terranes and produced placers in the vicinity of Koyukuk and Northern Unit Innoko are identified in Figure 3-6.

The majority of the mineralization found in the vicinity of the Refuge appears to be related to contact zones around granitic plutons along Koyukuk's northern boundary. Placer gold has been produced at various times at sites on Utopia Creek, Indian River, and Bear Creek (on the Hogatza River). From 1957 to 1975, the Bear Creek placer at Hogatza was worked by a dredge with cumulative production exceeding 200,000 ounces of gold. The dredge operated again from 1981 through 1984. The Utopia Creek operation, though non-float, produced significant amounts of gold from 1930 through 1962. Indian River was also a large-scale non-float operation with total production of 5,000 ounces from 1911 to 1965.

Hardrock mining has not occurred in the region but could occur in the future, as placer deposits can be traced to conditions favorable for mineralization (Miller and Ferrians 1968).

Inside the Refuge, indications of mineral presence are previous mining claims, two prospects (identified from the Bureau of Mines Mineral Industry Locator System records), and lead-copper-silver mineralization in the Sun Mountain Area (Miller and Ferrians 1968).

Seventy-seven lode claims located southwest of Bear Mountain and two other lode claims located in the southeast Zane Hills have been identified in Bureau of Land Management Records. These are no longer listed as valid claims. The two prospects noted in Bureau of Mines records are west of Sun Mountain and in the Zane Hills south of Caribou Mountain. Copper has been reported at both prospects.

A coal bearing unit (mapped by Patton 1966) crops out along the west edge of Koyukuk, south of the Kateel River. The coal layer is bituminous and at most six inches thick. The rock unit containing these coal deposits is called the Kaltag formation. It is about 5,000 feet thick on the refuge and consists primarily of shale, siltstone, and sandstone; it is north-trending. Coal

thicknesses increase southward in the formation where exposures along the west bank of the Yukon River are as much as 39 inches thick with inclusions of eight foot thick pockets (Chapman 1963). These exposures were mined from 1898 through 1902 for use by steamships on the Yukon River. The largest output was probably 2,000 tons from the Williams Mine about 40 miles downriver from Kaltag. This area of coal, from the Yukon River exposures to the Kateel River, is known as the Nulato field. Chapman (1963) notes that the coal is thin, irregular, laterally discontinuous, highly fractured, and steeply dipping and is probably suitable only for shallow small-scale local use.

3.2.6 Oil and Gas Occurrences and Potential

Both Koyukuk and Northern Unit Innoko are within the Yukon-Koyukuk geologic province, a broad wedge-shaped depression of Cretaceous and Tertiary volcanic and sedimentary rocks that stretches across westcentral and southwestern Alaska from the Brooks Range to the Yukon River delta. The province was classed as a possible petroleum province (Miller et al. 1959). However, subsequent studies indicate that the sedimentary rock types present in the province are generally unfavorable for deposits of oil and gas, having been involved in severe compression and dislocation (Patton 1973).

The earliest sedimentary rocks, probably marine shelf deposited, now form metamorphic borderland buttresses. Subsequent marine Cretaceous sediments, possibly 15,000 to 25,000 feet deep in places, appear to be poured-in volcanics and contain easily alterable tuffs. Little chance for sand development exists with these sediments. Some submarine fans, which can be favorable for oil and gas accumulation, may exist in these sedimentary rocks. However, the entire lower and mid-Cretaceous section is metamorphosed and highly deformed, making the potential for petroleum very low. Late Cretaceous sediments, though only gently deformed, are limited in extent and are in near-surface positions, which also indicate low potential.

Aeromagnetic profiles across the Koyukuk Flats indicate the presence of highly magnetic rocks at shallow depths. Surface mapping around the margin of the flats suggest that the Quaternary alluvial deposits are probably underlain by andesitic volcanic rocks of Early Cretaceous age (Patton 1973). The flats, except along the Kaltag fault, do not appear to contain any substantial thickness of Cenozoic sedimentary strata, which indicates that oil and gas accumulations are probably absent. One exploratory test hole, Nulato No.1, located west-southwest of the community of Nulato, was drilled to a depth of 12,000 feet entirely in Cretaceous sedimentary rocks.

Inside the Nowitna, possibilities are limited to the speculative presence of Tertiary sediments. West of the Refuge, the Galena Basin Cretaceous sediments may have potential.

Evidence for a Tertiary basin consists of Tertiary sediments at the Palisades and a gravity low along the north side of the Refuge. The low is delineated as a trough, about 10 or 20 miles wide, from Big Creek to Blind River and flanks the gravity high marking the southeast edge of the rim of the Yukon-Koyukuk Province (Barnes 1976). The low may have developed by down-dropping on the south side of the Kaltag Fault and may thus be as old as early or middle Tertiary (Patton and Hoare 1968). However, at this time, no identifiable oil and gas basin exists in this area or elsewhere within the refuge boundaries. Consequently, the oil and gas potential is probably low on the Nowitna.

Figure 3-6
Refuge mineral presence

Features

- Refuge Boundary
- Designated Wilderness
- Long-Poorman Area (Au, Pt, W, Sn)
- Tozimoran Creek Area (Au, Sn)
- Mineral Occurance (various colors according to the mineral(s) found at the location)

Miles
0 10 20 40
0 10 20 40
Kilometers

19-0021

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: July 30, 2008

161°0'0"W 160°0'0"W 159°0'0"W 158°0'0"W 157°0'0"W 156°0'0"W 155°0'0"W 154°0'0"W 153°0'0"W 152°0'0"W

66°0'0"N 65°0'0"N 64°0'0"N

Au
Ag, Pb, Cu
U, Th
Cu
U
Placer
U, Th
Ag, Au, Pb, Bi, W, Cu
Cu
Placer
Placer
Hughes
Placer
Placer
Placer
Ag, Pb, Zn, Cu, Sb, Au
Ag, Pb, Au
Cu
Placer
Dikes, limestone, altered andes
Koyukuk NWR
Huslia
Au, Sn
U, Th
Au, Ag
Tanana
Au
Au
Bituminous Coal
Bituminous Coal
Bituminous Coal
Koyukuk
Bituminous Coal
Nulato
Sand & Gravel
Galena
Bituminous Coal
Bituminous Coal
Northern Innoko NWR (Kaiyuh)
Pb
Ag
Placer
Kaltag
Ruby
Nowitna NWR
Au
Au
Au
Au
Au
Bituminous Coal
Au
Cu
Poorman

3.2.7 Water Resources

One of the five specific ANILCA purposes of the Refuge is to ensure the conservation of water resources, specifically, "to ensure . . . water quality and necessary water quantity within the refuge[s] for the conservation of fish and wildlife populations and habitats in their natural diversity." The abundant and mostly pristine freshwater resources within the Refuge support plentiful populations of fish, wildlife, and vegetation.

Water is one of the main ecological drivers on the Refuge. The Refuge encompasses more than 1,800,000 acres of wetlands and waters, including over 50,000 lakes and thousands of miles of rivers and streams (Table 3-6). Though precipitation across the Refuge is only 12 to 14 inches per year, permafrost hinders infiltration of water into the ground, thus creating lakes and wetlands. River flows are influenced by winter freezing, spring snowmelt and breakup, late summer rain storms, and springs. The timing, frequency, duration, and magnitude of low and high flow events on the streams and rivers affect both in-channel and floodplain habitats through disturbance and recharge of lakes and wetlands. These events also drive the use of the landscape by wildlife.

In 1994, the Alaska Region of the Service identified and evaluated threats to water resources in the 16 National Wildlife Refuges in Alaska. This effort was intended to help set priorities for hydrologic investigations that would support instream water–rights filings. Most of the streams on the Refuge were not judged to be threatened; however, past mining, mineral exploration, and village trash and sewage were identified as potential threats. A subsequent 'threats analysis' in 2007 yielded similar results.

Table 3-6. Acres of wetland vegetation classes on the Koyukuk, Nowitna, and Northern Unit Innoko.

	Refuge			Total
Vegetation Class	N. Unit Innoko	Koyukuk	Nowitna	Acres
Clear Water	38,118	161,709	29,521	229,348
Dwarf Shrub	80,768	45,568		126,336
Emergent	6,260	47,745		54,005
Lichen	3,845			3,845
Low Shrub	103,680	644,666	91,635	839,981
Low Shrub - Tussock Tundra		295,095	18,434	313,529
Moss	5,355			5,355
Turbid Water	9,620	53,202	17,525	80,347
Tussock Tundra		34,786		34,786
Wet Graminoid	22,215	36,048		58,263
Wet Sedge		93,062		93,062
Total Acres	**269,861**	**1,411,881**	**157,115**	**1,838,857**

3.2.7.1 Water Quantity

To date, there have been no refuge-wide water studies. Stream flow has been measured only on the Yukon and Koyukuk rivers outside the refuge boundaries, and not since 1982. No other stream flow or water quality studies or stations are known for the refuge.

The Service plans to conduct a comprehensive investigation of water quantity to support instream-flow water rights filings for the Refuge. Reconnaissance and selection of gauging sites was conducted in1998. Installation of flow gauge equipment is scheduled to begin within the next 10 years, with data collection planned for the subsequent 6 years.

3.2.7.2 Water Quality

The U.S. Fish and Wildlife Service, Division of Ecological Services, Fairbanks Field Office, conducted a contaminant study of water, sediments, and fish on the Koyukuk and Nowitna between 1986 and 1988 (Snyder-Conn et al. 1992). On the Nowitna, metal and metalloid contaminants were studied on the Sulatna and Sulukna rivers, Cross Lake, and one pond next to the Sulukna (Mueller et al. 1996). These studies essentially found no significant contamination in water, sediment, or fish tissues.

The Service plans to conduct a baseline water quality study in conjunction with the water quantity study. Water quality sampling will be done at selected sites on the Refuge. Sampling is planned to begin within 10 years and continue for 6 years.

3.2.8 Fire Disturbance Regime

Wildfires (fire) in the (black spruce-dominated) boreal forest tend to be large and frequent due to the dry continental climate, the flammable nature of fuels, and the continuity of fuels extending from ground level to the tree crowns. The common feathermoss-dominated understory forms a large, horizontally continuous, and well-aerated fuelbed. Most fires in the boreal forest are either intense ground fires or crown fires of sufficient intensity to consume or kill both the overstory and the entire understory vegetation. However, these fires do not burn with consistent intensity or severity over these large areas and often leave a patchwork of unburned to moderately-burned areas that create an irregular fire perimeter. Wildfires often smolder deep in the duff and can hold over through long periods of high relative humidity and moderate rainfall.

The leaf litter and shading found under deciduous and mixed forests combines to create moist cool conditions and a compact litter layer that is less combustible than those found in conifer forests. Surface fuels in the hardwood and mixed forests typically do not form a continuous ladder from the ground to the tree crowns, so surface fires are common. Deciduous forests often provide a natural fuel break where fire will typically smolder in the understory and spread slowly.

Shrub habitats and sedge tussock-tundra are characterized by light flashy fuels whose moisture content responds quickly to modest changes in relative humidity. These fires tend to burn quickly and intensely, skipping over and around standing water between the tussocks and pockets of wet sphagnum moss. The presence of wind contributes to high rates of spread and short- to medium-range spotting. With a little moisture, these fires go out quickly; they do not hold over for long. Moderate intensity wildfires may consume the above ground plant but seldom burn the below ground part or kill the plant. In drier conditions, fires in the shrub habitat and tussock-tundra may have high rates of spread and intensity, which can easily carry the fire into adjacent conifer forests.

3.2.8.1 Fire Occurrence and Frequency

There is evidence of fire throughout most of the Refuge. Historically, fire has strongly influenced the distribution and diversity of plant and animal communities in interior Alaska. Most fires are lightning caused in the interior. There is no evidence of anthropogenic fire on the Refuge.

The fire return interval for the Koyukuk is 275 years and 192 years on the Nowitna, based on the past 50 years of fire records. Such a short timeframe does not accurately describe the true fire return interval for the Refuge. A range of estimated mean fire intervals has been determined for interior black and white spruce forest types. The estimated range for black spruce is 25–130 years, depending upon study location and variation of the black spruce forest type studied (e.g., open black spruce-lichen versus closed black spruce-lichen). The estimated range for upland white spruce is 50–240 years, depending upon study location and variant of white spruce studied.

3.2.8.2 Fire Size

Wildland fires on the Refuge will range from less than one acre in size to as large as 200,000 acres. Fires in the black and white spruce forest types tend to be 125,000 acres or larger. Natural fire size is determined by a variety of factors.

- The later in the season a fire starts, the less time it has to spread.
- Weather not only affects initial spread but eventual fire growth.
- Fires can hold over during long periods of moist weather and become active again after a drying period.
- Wind can cause a fire to quickly grow.
- Fuel continuity determines whether a wildland fire can and will continue to grow.
- Wetlands and rocky areas tend to form barriers to spread that can only be breached by spotting.
- Hardwood stands, wet areas, and old burn scars may also serve as barriers because the reduced fuel load in these areas usually limits fire behavior and slows fire spread.

Consequently, some fires may burn only a few square feet, while others continue to burn throughout the summer affecting thousands or hundreds of thousands of acres.

3.2.8.3 Fire Season

The fire season on the Refuge can begin as early as Memorial Day and end as late as the first week of September. Most of the fire activity occurs during July when fuels have matured and are at their lowest live fuel moisture levels.

3.2.8.4 Impacted Villages Around the Refuge

Seven villages have the potential to be affected by fire on or adjacent to the Refuge. The village of Huslia is located within the Koyukuk. The villages of Ruby, Galena, Koyukuk, Nulato, Kaltag, and Hughes are located outside of the refuge boundaries.

3.3 Biological Environment

3.3.1 Vegetation

Riparian vegetation is dominated by willow *(Salix spp.)*, cottonwood (*Populus balsamifera ssp. balsamifera)*, and white spruce *(Picea glauca)*. As rivers and creeks move through the floodplain, outside banks and vegetation are eroded into the river, and inside banks are built up through the deposition of silt, sand, and gravel. Recent inside-bank soil deposits along rivers and creeks are well drained and are usually free of permafrost. These factors are conducive to the establishment of varying age groups of willow as one moves inland away from the river channel. On extremely winding rivers such as the Yukon, large oxbows are common. Within this area, concentric bands of willow or cottonwood of different ages often form. Grass lakes are sometimes intermingled with these bands. Common riparian vegetation include willow and alder (*Alnus viridis ssp. crispa and A. incana ssp. tenufolia*) thickets along gravel bars at the water's edge, stands of cottonwood trees higher on the bank, and bands of white spruce varying in width on the higher banks. Stands of white birch *(Betula papyrifera)* and quaking aspen *(Populus tremuloides)* often mix with the white spruce forest along the river corridors.

Treeless bogs are the predominant vegetation type in the center of the Koyukuk and in scattered locations on the Nowitna and Northern Unit Innoko. Bog vegetation consists of dwarf birch (*Betula nana and B. glandulosa*), bog blueberry (*Vaccinium uliginosum*), Labrador tea (*Ledum palustre*), leatherleaf (*Chamaedaphne calyculata*), myrtle (*Myrica gale*), bog rosemary (*Andromeda polifolia*), bog cranberry (*Oxycoccus microcarpus*), cottongrass (*Eriophorum spp.*), sundew (*Drosera anglica, D. rotundifolia*), sedges, feather mosses, and sphagnum moss *(Sphagnum spp.)*. Intermixed with the bog are drier ridges that are vegetated with willow, alders, resin birch (*Betula glandulosa*), black spruce, and tamarack (*Larix laricina*).

Wetland vegetation is quite specific and varied. Refuge wetlands include upland basins, ice-formed lakes on the flats, river flooded lowlands, oxbows, and bog lakes. Spring runoff, rain, and river flooding recharges the lakes. Favorable water temperatures in the shallow lakes create ideal conditions for the growth of aquatic plants such as duckweed (*Lemna* sp.), horsetail (*Equisetum spp.*), water milfoil (*Myriophyllum sp.*), mare's tail (*Hippuris vulgaris*), and smartweed (*Polygonum spp.*). One or more of 12 species of pondweed (*Potamogeton spp.*) occur in almost all lakes. Indicators of bog lakes include water lily (*Nuphar polysepalum*), pygmy water lily (*Nymphaea tetragona*), water hemlock (*Cicuta douglasii and C. mackenziana*), water parsnip (*Sium suave*), buckbean (*Menyanthes trifoliata*), and bladderwort (*Urtricularia macrorhiza*). Shorelines of bog lakes vary in character but nearly always contain buckbean (*Menyanthes trifoliata*), wild calla (*Calla palustris*), various sedges (*Carex spp.*), and burreed (*Sparganium hyperboreum*). Several species of Graminoids, including sedge, bluejoint grass (*Calamagrostis canadensis*), and foxtail (*Hordeum spp.*), are found on the exposed shorelines. A variety of forbs grow on recently exposed soils along shorelines. Cattail (*Typha latifolia*) is an invasive species on the Refuge.

Shallow, seasonally flooded basins or grass lakes are common along the Koyukuk, Yukon, and Nowitna rivers. Grass lakes are usually wetlands during spring breakup and flooding, and in summer become dry meadows, many of which show the beginnings of shrub and forest succession. The drier portions of grass lakes are vegetated primarily by bluejoint grass and occasionally arctic-bentgrass (*Arctagrostis latifolia*). *Carex aquatilis, C. rostrata, C. capitata* and other sedges and marsh cinquefoil (*Potentilla palustris*) dominate in the wetter portions.

There are about 14,000 lakes and ponds on the Nowitna, where wetland acreage is approximately 30,000 acres. The Koyukuk and Northern Unit Innoko have an estimated 15,000 water bodies, comprising approximately 280,000 acres and 5,500 miles of rivers and streams.

Forests cover 88 percent of the Nowitna and 41percent of the Koyukuk and Northern Unit Innoko. Black spruce *(Picea mariana)* is the dominant tree species followed by white spruce *(Picea glauca)*, white birch *(Betula papyrifera)*, quaking aspen *(Populus tremuloides)*, and balsam poplar *(Populus balsamifera ssp. balsamifera)*. While there are pure stands dominated by a single tree species, stands typically mix and grade into one another, depending on underlying soil type.

The open conifer forests have 25–60 percent tree cover and are found on moderately to poorly drained soils. This type is composed primarily of black spruce but often includes tamarack (*Larix laricina*) and willows. This type is frequently found on north facing slopes and poorly drained lowlands that are usually underlain by permafrost. Ground cover species in this forest include bog blueberry, Labrador tea, sedges, and mosses. In many areas, a thick blanket of lichen species entirely covers the ground, forming an open conifer-lichen association. This type dominates the Nowitna, making up 42 percent of the area and 7 percent of the Koyukuk.

The closed conifer forests occur on moist to well drained sites from the lowlands to mountain slopes and are particularly well developed on alluvial sites along the major rivers. Closed forests typically have 60–100 percent cover. The dominant tree species is white spruce, which may grow to 80–100 feet tall, forming the largest stature forest found on the Refuge. Understory species include northern toadflax (*Geocaulon lividum*), highbush cranberry (*Viburnum edule*), azalea (*Rhododendron lapponicum*), prickly rose (*Rosa acicularis*), sweetvetch (*Hedysarum alpinum*), and various species of feathermoss. This type comprises about two percent of the Refuge.

Deciduous forests occur on well to imperfectly drained sites—mainly on hills where strips of birch forest line hillside streams, and aspen is present on south facing sandy hillsides. White birch, aspen, and balsam poplar dominate the overstory. The deciduous forest reaches its greatest extent on the Nowitna, where it covers 30 percent of the total surface area—but only 3 percent of the Koyukuk.

Mixed forests have 25–100 percent cover of deciduous broadleaf trees mixed with conifer trees. Mixed forests are distributed mainly along the major water courses, especially on islands in the Yukon and Koyukuk rivers, and on relatively dry, south facing hillsides where drainage is good and permafrost is absent. This forest type consists of moderately tall (50 to 80 feet) paper birch, quaking aspen, and cottonwood, mixed with white-spruce. Common understory species found in mixed forest include highbush cranberry, currant (*Ribes triste*), bunchberry (*Cornus canadensis*), and prickly rose. This forest type comprises six percent of the Koyukuk and four percent of the Nowitna.

Conifer woodlands, sometimes called muskeg, have 10 to 25 percent tree cover and are found on moderately to poorly drained soils. These woodlands contain short, sparse, tree growth (mainly black spruce and some tamarack). The ground cover resembles treeless bog and is dominated by shrub species such as Labrador tea, bog rosemary, bog blueberry, mountain cranberry, bog cranberry, and crowberry (*Empetrum nigrum*). Various graminoid and moss species may be common, including cottongrass, sedges, and mosses (especially *Sphagnum* moss). This type makes up 26 percent of the Koyukuk and 10 percent of the Nowitna.

The Refuge contains several **non-forest shrub, herbaceous, and graminoid (grass-sedge)** vegetation cover types.

The dwarf shrub-graminoid tussock peatland community contains slow-growing dwarf shrubs less than 1.5 feet tall, and frequently occurs on poorly drained organic soils. Mosses and lichens cover the surface. Dominant shrub species include *Ledum decumbens, Chamaedaphne calyculata, Vaccinium uliginosum, V. vitis-idaea, Betula glandulosa* (or *B. nana*), *Eriophorum vaginatum, Carex bigelowii, Rubus chamaemorus, Sphagnum spp.*, *Dicranum spp*., *Cladina spp*., and *Cetraria spp*. This is a dominant vegetation type on the Koyukuk (27 percent) but a minor type on the Nowitna (2 percent).

The alluvial/lowland tall shrub type is dominated by deciduous shrubs ranging from 1.5 to 16 feet in height. The tall shrub communities are found primarily on floodplains and are dominated by willows (*Salix alaxensis, Salix planifolia pulchra, Salix arbusculoides, and Salix bebbiana*), and in some areas, alder (*Alnus incana ssp. tenufolia, A. viridis ssp. crispa*). The main understory species include *Vaccinium vitis-idaea, Linnaea borealis, Calamagrostis canadensis,* and *Equisetum arvense.* This type makes up four percent of the Nowitna and three percent of the Koyukuk.

The graminoid tussock-shrub community has a similar plant composition to tall shrub type but is dominated by *Eriophorum* tussocks and lesser amounts of dwarf shrub and herbaceous cover. This type is transitional to arctic and alpine tundra in some areas. It is most common on the Koyukuk, where it makes up 14 percent of the cover.

The prostrate dwarf shrub tundra vegetation type is characterized by relatively bare alpine vegetation dominated by low-growing matted dwarf shrubs. This community is rich in lichens. Dominant species include *Dryas octopetala, Salix phlebophylla, Vaccinium uliginosum, V. vitis-idaea, Empetrum nigrum, Diapensia lapponica, Salix arctica, Arctostaphylos alpina, Sphaerophorus globosus, Cetraria nivalis, C. cucullata, Alectoria ochroleuca, Thamnolia subuliformis,* and *Stereocaulon spp*. This type comprises one percent of the Koyukuk and less than one percent of the Nowitna.

The herbaceous vegetation class is dominated by herbaceous plants and includes grasses, sedges, and flowering plants. The main subclasses of this vegetation type include graminoid-dominated bogs, marshes, and meadows. The graminoid-dominated bog has a moss-dominated surface underlain by peat that is often saturated with water. Typical graminoids in this subclass are *Eriophorum russeolum, Carex limosa*, and *Carex chordorrhiza.* The graminoid meadow is relatively dry and dominated by *Calamagrostis canadensis.* It is often associated with old river meanders. The graminoid marsh primarily occurs at the margins of lakes and ponds. The most important graminoids in this subclass are *Carex aquatilis,* and *Carex rostrata.* This class occurs along the margins of most wetlands on the Refuge. Approximately two percent of both the Nowitna and Koyukuk are comprised of this class.

Other minor vegetative types occur on the Refuge. There are upland areas that surround the wetland floodplain basins. On the Koyukuk, small mountain ranges occur on the east, west, and north boundaries of the Refuge. On the Northern Unit Innoko, the Kaiyuh Hills occur along the southern boundary. On the Nowitna, hills occur along all four sides of the refuge. Mountaintops on the Refuge typically are scarcely vegetated rock scree that may extend down the mountain in fingers of unstable rock. Below the scree, communities of prostrate dwarf shrub tundra, alpine meadows, and dwarf shrub tussock tundra predominate. These communities grade into subalpine broadleaf shrub communities and a treeline composed of stunted white spruce. Alpine habitats are particularly rich in lichen species such as *Cetraria*

nivalis, *C. cuculata*, *Alectoria ochroleuca*, *Thamnolia subuliformis*, *Stereocaulon spp.*, *Cladina spp.*, and *Cladonia spp.* Subalpine broadleaf shrub communities are dominated by alder and willow (*Salix planifolia* ssp. *pulchra*). Estimated cover of these alpine and subalpine habitats is three percent on the Koyukuk and one percent on the Nowitna.

Figure 3-7, Figure 3-8, and Figure 3-9 depict the vegetation types based on the Ducks Unlimited (1998) classification.

Land cover mapping was done by Ducks Unlimited (1998)based on a modified Alaska Vegetation Classification (Viereck et al. 1992) during three different time periods. The northwest section of the Northern Unit Innoko was completed in 1999; the Nowitna was completed in 2000; and the Koyukuk was completed in 2001. The classification of the Northern Unit Innoko contains 35 different vegetative classes; the Nowitna contains 32 vegetative classes; and the Koyukuk contains 33 vegetative classes. There are 12 main vegetative classes that cover the bulk of the Refuge. They are described below and summarized in Table 3-7, Table 3-8, and Table 3-9.

Open Needleleaf forests have 25 to 60 percent tree crown canopy cover. This type is found on sites ranging from well drained timberline to poorly drained soils. This type is composed of primarily black and white spruce, some tamarack, and willows. Ground cover species in this forest type include bog blueberry, Labrador tea, sedges, lichens, and feather mosses.

Needleleaf Woodland forests have from 10 to 25 percent tree canopy cover. This type is often referred to as muskeg and is found on sites ranging from near the latitudinal and elevational treeline to cold, wet, and poorly drained soils. These forests are composed of primarily black and white spruce and scattered white birch and willows. Ground cover species include alder, cloudberry, dwarf birch, bog blueberry, Labrador tea, mountain cranberry, crowberry, cottongrass, sedges, horsetail, feather and sphagnum mosses, and lichens.

Closed Mixed Needleleaf/Deciduous forests are populated by both conifer and deciduous tree species, but neither species has a clear dominance. Both conifer and deciduous species contribute 25 to 75 percent of the total canopy cover and tree cover totals at least 10 percent. This forest type is found on a range of sites from well drained to moderately drained to floodplains and slopes to bases of south facing slopes to relatively warm dry sites. Common tree species include white spruce, paper birch, quaking aspen, and balsam poplar. Understory species include alders, willows, prickly rose, high bush cranberry, American red current, spirea, mountain cranberry, bog blueberry, Labrador tea, bluejoint, bunchberry, twinflower, bluebell, horsetail, fireweed, and feathermosses.

Closed Deciduous – Birch forests are dominated by white birch and have at least a 60 percent tree cover. This forest type is commonly found on upland sites that are moderately to well drained. Common tall shrubs include alder, prickly rose, and high bush cranberry. Dwarf shrubs may include only mountain cranberry and twinflower. The herb layer usually is dominated by bluejoint. Bluebell and horsetail may also be common. Mosses and lichens are rare.

Open Mixed Needleleaf/Deciduous forests are comprised of paper birch and either white or black spruce. Total tree cover is 25–60 percent. They are found on relatively wet and poorly drained wetland sites. Alder and willow are the dominant tall shrubs. Understory species include dwarf birch, spiraea, bog blueberry, mountain cranberry, Labrador tea, and bluejoint. Feathermosses dominate the ground layer. Both foliose and fruticose lichens are common.

Woodland Needleleaf – Lichen forests are the same as the Needleleaf Woodland except that they are in a late seral stage.

Open Needleleaf – Lichen forests are the same as the Open Needleleaf except that they are in a late seral stage.

Closed Mixed Deciduous forests are the same as the Closed Mixed Needleleaf/Deciduous except that successionally they are in an early to mid-seral stage and the fore mentioned type is in a late seral stage.

Wet Graminoid includes the tree-less bogs, which are the predominant vegetation type in the center of the Koyukuk and in scattered locations of the Nowitna and Northern Unit Innoko. Bog vegetation on the Refuge consists of various species of cotton-grass, dwarf and shrub birch, bog blueberry, Labrador tea, leatherleaf, myrtle, sedges, and mosses, especially sphagnum moss. Other species of bog habitat include bog rosemary, bog cranberry, and sundew.

Low Shrub communities are dominated by low shrubs (eight inches to five feet in height). These communities have at least 25 percent cover by shrubs at least eight inches tall; trees provide less than 10 percent cover and tall shrubs provide less than 25 percent cover. Dominant plants are generally alders, willows, and shrub birch. Myrtle, cinquefoil, and ericaceous shrubs may dominate some communities. Some ericaceous shrubs transcend the boundary between dwarf shrub and low scrub. In general, bog blueberry and Labrador tea are considered to be low shrubs. Crowberry, mountain cranberry, bearberry, alpine azalea, and diapensia are considered to be dwarf shrubs.

Tall Shrub communities have at least 25 percent cover of tall (five feet) shrubs. Trees contribute less than 10 percent cover and are often absent. Low and dwarf shrubs may be present or absent. Tall shrub communities are found primarily in floodplains and streambanks. They are dominated by willows, and in some areas, alder. Chief understory species include bog blueberry, twinflower, bluejoint, and horsetail.

Low Shrub Tussock-Tundra communities are characterized by an open canopy of low shrubs. They have at least 25 percent shrub cover and are dominated by tussock-forming sedges, usually tussock cottongrass but sometimes by Bigelow sedge *(Carex bigelowii)*. This community occurs on poorly drained organic soils underlain by permafrost. Trees are absent or very scarce. Mosses and dwarf shrubs form a mat surrounding the tussocks. Common shrubs include dwarf and resin birch, Labrador tea, mountain cranberry, and bog blueberry. Herbs other than the tussock-formers are generally scarce, though cloudberry is locally common.

Figure 3-7
Koyukuk vegetation types

Landcover

- Open Water
- Perennial Ice/Snow
- Barren Land (Rock/Sand/Clay)
- Decidiuous Forest
- Evergreen Forest
- Mixed Forest
- Dwarf Scrub
- Shrub/Scrub
- Grassland/Herbaceous
- Sedge/Herbaceous
- Woody Wetlands
- Emergent Herbaceous Wetlands
- Developed, Low Intentsity
- Developed, Medium Intentsity

Miles
0 5 10 20

0 5 10 20
Kilometers

19-0016

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: Sept. 17, 2008

160°0'0"W 159°0'0"W 158°0'0"W 157°0'0"W 156°0'0"W 155°0'0"W 154°0'0"W

66°0'0"N

65°0'0"N

Hughes

Nogahabara Sand Dunes

Huslia

Koyukuk NWR

Koyukuk

Yukon River

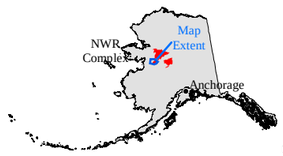
Ruby

Figure 3-8
Northern Unit Innoko vegetation types

Landcover

- Open Water
- Perennial Ice/Snow
- Barren Land (Rock/Sand/Clay)
- Decidiuous Forest
- Evergreen Forest
- Mixed Forest
- Dwarf Scrub
- Shrub/Scrub
- Grassland/Herbaceous
- Sedge/Herbaceous
- Woody Wetlands
- Emergent Herbaceous Wetlands
- Developed, Low Intentsity
- Developed, Medium Intentsity

Miles
0 2.5 5 10
0 2.5 5 10
Kilometers



N

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: May 13, 2008

19-0017

159°0'0"W 158°0'0"W 157°0'0"W

Koyukuk

Nulato

Yukon River

Galena

Kaltag

Northern Innoko NWR (Kaiyuh)

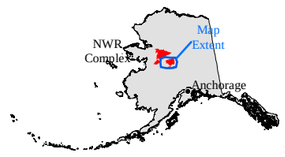
159°0'0"W 158°0'0"W 157°0'0"W

Figure 3-9
Nowitna vegetation types

Landcover

- Open Water
- Perennial Ice/Snow
- Barren Land (Rock/Sand/Clay)
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Dwarf Scrub
- Shrub/Scrub
- Grassland/Herbaceous
- Sedge/Herbaceous
- Woody Wetlands
- Emergent Herbaceous Wetlands

Miles
0 5 10 20
0 5 10 20
Kilometers



19-0008

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: May 13, 2008

156°0'0"W 155°0'0"W 154°0'0"W 153°0'0"W

65°0'0"N

64°0'0"N

Yukon River

Tanana

Ruby

Nowitna NWR

Poorman

Table 3-7. Acreage summary of land cover classes on the Koyukuk.

Land Cover Class	Federal Acres	Private Acres	Percent of Refuge
Open Needleleaf	817,352	146,565	18.2
Needleleaf Woodland	727,606	90,307	16.2
Closed Mixed Needleleaf/Deciduous	77,323	29,919	1.7
Closed Deciduous	103,585	44,010	2.3
Open Mixed Needleleaf/Deciduous	170,839	42,310	3.8
Woodland Needleleaf – Lichen	145,515	15,275	3.2
Open Needleleaf – Lichen	122,397	23,397	2.7
Closed Mixed Deciduous	55,718	16,609	1.2
Wet Graminoid	28,808	7,241	0.6
Low Shrub	559,103	85,563	12.4
Tall Shrub	166,544	32,442	3.7
Low Shrub Tussock – Tundra	270,579	24,516	6.0

Table 3-8. Acreage summary of land cover classes on the Northern Unit Innoko.

Land Cover Class	Federal Acres	Private Acres	Percent of Refuge
Open Needleleaf	37,062	48,210	5.6
Needleleaf Woodland	35,662	29,319	4.8
Closed Mixed Needleleaf/Deciduous	13,615	34,401	1.8
Closed Deciduous	4,107	11,615	0.6
Open Mixed Needleleaf/Deciduous	16,828	34,203	2.3
Woodland Needleleaf – Lichen	8,470	5,569	1.1
Open Needleleaf – Lichen	88,668	59,509	12.8
Closed Mixed Deciduous	0	0	0
Wet Graminoid	9,919	12,296	1.3
Low Shrub	53,346	50,334	7.1
Tall Shrub	5,894	8,952	0.8
Low Shrub Tussock – Tundra	25	15	<0.1

Table 3-9. Acreage summary of land cover classes on the Nowitna.

Land Cover Class	Federal Acres	Private Acres	Percent of Refuge
Open Needleleaf	972,863	98,413	47.0
Needleleaf Woodland	170,783	16,745	8.3
Closed Mixed Needleleaf/Deciduous	220,436	48,481	10.7
Closed Deciduous	101,780	15,582	4.9
Open Mixed Needleleaf/Deciduous	49,181	5,780	2.4
Woodland Needleleaf – Lichen	28,887	1,636	1.4
Open Needleleaf – Lichen	0	0	0
Closed Mixed Deciduous	13,405	2.123	0.7
Wet Graminoid	10,913	2,627	0.5
Low Shrub	81,564	10,072	4.0
Tall Shrub	9,364	2,372	0.5
Low Shrub Tussock – Tundra	16,971	1,463	0.8

3.3.1.1 Non-Native Invasive Plants

Invasive non-native species pose a significant risk to ecological stability and integrity. Opportunistic investigation of invasive plant species on the Refuge during other operations has revealed a very limited occurrence. Lambsquarter was observed in two places on the upper Nowitna River in 2006. Foxtail was observed on the Nowitna Refuge at the mouth of Junekaket Slough in 2007. Several non-native plants have been observed in Galena, including lambsquarter, common chickweed, pineappleweed, common plantain, dandelion, clover, timothy, foxtail barley, cattails, and white sweet clover. Of these, white sweet clover is considered the most invasive, and removal efforts are ongoing. Plans are underway to develop a monitoring strategy to identify non-native plants in other villages within the region.

3.3.2 Fish and Wildlife

3.3.2.1 Fish

The Refuge contains an extensive assemblage of fish communities and their habitats. These waters provide spawning, rearing, feeding, overwintering, or migratory habitats for 21 reported species of fish (Table 3-10) (Adams and McLain 2007, USFWS 1991, USFWS 1993). Most species are classified in the Salmonidae family with individual species representing eight other families. The two life history strategies used by these species are represented by the anadromous behaviors of salmon and whitefish and the purely freshwater dependence of Arctic grayling and northern pike.

Despite the importance of several species to subsistence, commercial, and sport fisheries and the value of all species to the aquatic production, natural diversity, and food webs of the Refuge, little is understood about the life history, distribution, behaviors, and harvest of fish on the Refuge. Most of the available information is related to salmon, and their basic life history is understood in the larger context of the Yukon River system. However, comprehensive information about adult salmon stock abundance, population structure, timing, distribution, and

critical habitats on the Refuge is lacking. Additionally, information about the characteristics of juvenile salmon populations on the Refuge or factors affecting them is absent.

Whitefish are an important Refuge resource. Little information is available about these species. Whitefish provide subsistence users with sustenance during seasons when salmon are not available. Emerging commercial fisheries have the potential to harvest large numbers. These fish act as an important prey base for wildlife and other fish species.

Sheefish are targeted in sport fisheries. Similar to salmon, the migratory habits of several of these species make refuge stocks susceptible to harvest impacts outside of the Refuge. However, unlike salmon, few fundamental population characteristics or critical habitats have been identified.

While some information exists for other harvested species in the region, such as northern pike and Arctic grayling, little is known about these species within the Refuge. Also, information about species that are not used directly by humans, but may be important for predator-prey relationships and other ecological aspects (e.g., lake chub and trout perch) is nonexistent. Additionally, although salmon harvests in some villages are documented annually by the Service (Gerken and Holder 2005, Gerken 2006, Gerken 2008) and ADF&G (Busher and Hamazaki 2005), with non-salmon harvests occasionally described (Andersen 2007, Andersen et al. 2004, Marcotte and Haynes 1985), detailed harvest information for all species is lacking. Descriptions of the more commonly known species follow.

Northern pike are a common species on the Refuge and typically inhabit the lower portions of larger rivers and most lakes of suitable depth (USFWS 1991, USFWS 1993). Fish begin spawning during the spring of their third year, and fry emerge one to three weeks after spawning (Cheney 1971). Soon after emergence, they become active predators of suitable-sized fish and invertebrates. Northern pike have been captured in the Gisasa River, the mouth of the Kateel River (Alt 1978), the Hogatza River, Clear Creek (Mueller et al. 1996), the South Fork of the Huslia River (Wiswar 1994a), the North Fork of the Huslia River, and in Billy Hawk Creek (Wiswar 1994a, Wiswar 1994b) on the Koyukuk. Within the Nowitna, this species has been captured in the Sulatna, Sulukna, and main stem Nowitna rivers (Wiswar 1994a). Northern pike were also captured in Camp and Eddy creeks on the Northern Unit Innoko (Mueller et al. 1996). Based on a 1994–1996 radio telemetry study, northern pike tagged in the Kaiyuh Flats overwintered in three areas: the North Lakes area with most fish relocated in Duck Lake; the South Lakes area with most fish relocated in Little Brush Island Lake; and in the Khotol River near Manslaughter Slough (Taube and Lubinski 1996). These fish exhibited high fidelity to overwintering sites, unlike spawning and summering areas where fish were greatly dispersed. Adult northern pike in the Kaiyuh Flats were not reliant on movements to the Yukon River for their seasonal needs.

Broad whitefish are highly migratory and some stocks in the Yukon River basin are considered to be anadromous (Brown et al. 2007). They enter refuge waters from the main stem of the Yukon River to feed in the lower river systems and river connected lakes soon after breakup (Alt 1985). Spawning occurs in the fall. Although broad whitefish have been captured in the Gisasa River, at the mouth of the Kateel River (Alt 1978), in Billy Hawk Creek (Wiswar 1994a, Wiswar 1994b), in the North Fork main stem (Wiswar 1994b), and the South Fork of the Huslia River on the Koyukuk, no spawning areas have been identified on the Koyukuk or the Northern Unit Innoko (USFWS 1993). Within the Nowitna, this species has been captured in the Nowitna River (Alt 1978, Wiswar 1994a). This species is an important forage fish for aquatic and terrestrial predators.

As with broad whitefish, **humpback whitefish** are highly migratory and some stocks are considered to be anadromous (Brown et al. 2007). The timing of arrival in refuge waters is similar to broad whitefish, with both species using overlapping habitats for feeding. This species also spawns in the fall. Humpback whitefish have been captured in the Gisasa River, at the mouth of Kateel River (Alt 1978), and in the North Fork of the Huslia River (Wiswar 1994b) on the Koyukuk, but spawning has not been documented in the Koyukuk and Northern Unit Innoko (USFWS 1993). Humpback whitefish are common in the Nowitna River (Alt 1978, USFWS 1991) and have been identified as spawning in the lower reaches of the river (Alt 1985). Humpback whitefish are also an important forage species.

Like the previous whitefish species**, least cisco** are highly migratory and some stocks are thought to be anadromous (Brown et al. 2007). Their run timing and habitat use appear to be similar to broad and humpback whitefish (Alt 1983), with spawning occurring in the fall. Documented presence includes at the mouths of the Gisasa and the Kateel rivers on the Koyukuk and at the mouth of the Nowitna River (Alt 1978). Least cisco also provide forage for aquatic and terrestrial predators.

Sheefish or inconnu are also highly migratory with several stocks considered to be anadromous (Brown et al. 2007). Their distribution across the Refuge is limited to the larger river systems and the main channel of the Yukon River (USFWS 1991, USFWS 1993). Sheefish overwinter in the lower Yukon River and migrate into the larger rivers after breakup to forage in tributaries (Alt 1985). In general, sheefish are thought to be non-consecutive year spawners, with females spawning every other year or less frequently beginning at 8–12 years of age (Brown 2000). Males begin spawning at age 6–8. Spawning occurs in late September to mid-October with fry appearing in early spring. Fish within the Koyukuk spawn in the Koyukuk River near the village of Hughes (Alt 1978) and in the Alatna River (R. Brown 2008). Fish found on the Nowitna spawn upstream of the refuge boundary in the Sulukna River (Alt 1985). Sheefish have also been captured at the mouth of the Kateel River (Alt 1978) and in the main stem of the Huslia River on the Koyukuk (Wiswar 1994a). Important sheefish prey include whitefish, northern pike, longnose suckers, lamprey, and salmon parr and smolts (Alt 1983).

Arctic grayling are resident fish that congregate at the mouth of clear water tributaries in the large river systems prior to spawning in mid-May to early June (USFWS 1991, USFWS 1993). Arctic grayling begin spawning at age three, with fry emerging within a month of spawning (Alt 1983). Soon after emergence, the fry seek slower velocity water. The documented distribution of Arctic grayling on the Refuge includes the Gisasa River, the mouth of the Kateel River (Alt 1978), the Honhosa River (Wiswar 1994b), and Clear Creek (Mueller et al. 1996) on the Koyukuk, as well as the main stem Nowitna River above the confluence with the Big Mud River (Alt 1985). Insects of the orders Diptera and Hemiptera constitute the major food items.

Chum salmon on the Refuge are part of the Yukon River run and include two distinct groups (USFWS 1991, USFWS 1993). Summer chum salmon are more abundant, arrive in late June to mid-July, and spawn though August. Spawning areas on the Koyukuk include the Koyukuk, Dakli, Gisasa, Indian, and Kateel rivers; the North Fork of the Huslia River; and Billy Hawk Creek (Barton 1984). Within the Nowitna River, adult summer chum salmon have been captured in the Sulatna River (Mueller et al. 1996). An area near the Nowitna River confluence with the Big Mud River has been identified as a spawning area (Alt 1985). Fall chum salmon typically pass the Nowitna during August on their way to their primary spawning areas in the middle and upper Yukon River basin. However, adult fall chum salmon have been captured in

the Sulukna River, but a spawning area has not been identified (Alt 1985). Eggs develop through the fall and winter, with fry emerging in early spring. Soon after emergence, the fry begin migration to salt water and return in three to six years (Salo 1991), although four-year-old chum salmon account for most of the annual return (Buklis and Barton 1984).

Coho salmon on the Refuge are also part of the Yukon River run. These fish enter the area in mid-September and spawn throughout late fall (USFWS 1991, USFWS 1993). Within the Refuge, adult coho salmon have only been captured in the main stem of the Nowitna River (Wiswar 1994a), with a spawning area suspected near the mouth of Our Creek (Alt 1985). Eggs develop throughout the fall and winter, with fry appearing the following spring. Coho salmon parr typically remain in fresh water one to three summers and smolt the following spring (Sandercock 1991). These fish generally rear for one year in the ocean before returning to freshwater to spawn. Four-year-old fish comprise most of the annual return.

As with chum and coho salmon, **Chinook salmon** on the Refuge are part of the Yukon River run (USFWS 1991, USFWS 1993). Returning adults arrive in Refuge waters in June and July, and they typically complete spawning by early September. Documented spawning areas in the Koyukuk include the Koyukuk, Dakli, Gisasa, Indian, and Kateel rivers (Barton 1984), as well as areas on the Hogatza River upstream of the refuge boundary (Eiler et al. 2004, 2006a, 2006b). Spawning areas have also been identified in the Nowitna River (Eiler et al. 2004, Eiler et al. 2006a, Eiler et al. 2006b). Eggs develop throughout the fall and winter, with fry appearing early the next spring. Chinook salmon parr typically rear for one year in freshwater and smolt during the spring of their second year of life (Healey 1991). Once the smolt enter the ocean, they generally rear and mature for three to six years before returning to freshwater to spawn. Five-year-old fish account for most of the anual return.

Table 3-10. Fish of the Koyukuk, Nowitna, and Northern Unit Innoko

Common Name	Scientific name (in taxonomic order)
	PETROMYZONTIDAE
Arctic lamprey	*Lampetra camtschatica*
	CYPRINIDAE
Lake chub	*Couesius plumbeus*
	CATASTOMIDAE
Longnose sucker	*Catostomus catostomus*
	ESOCIDAE
Northern pike	*Esox lucius*
	UMBRIDAE
Alaska blackfish	*Dallia pectoralis*
	SALMONIDAE
Bering cisco	*Coregonus lauretta*
Broad whitefish	*Coregonus nasus*
Humpback whitefish	*Coregonus pidschian*
Least cisco	*Coregonus sardinella*
Round whitefish	*Prosopium cylindraceum*
Sheefish (inconnu)	*Stenodus leucichthys*
Arctic grayling	*Thymallus arcticus*
Pink salmon*	*Oncorhynchus gorbuscha*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Sockeye salmon	*Oncorhynchus nerka*
Chinook salmon	*Oncorhynchus tshawytscha*
Dolly Varden char	*Salvelinus malma*
	PERCOPSIDAE
Trout perch	*Percopsis orniscomaycus*
	GADIDAE
Burbot	*Lota lota*
	COTTIDAE
Slimy sculpin	*Cottus cognatus*

** species reported from Koyukuk Refuge only*

3.3.2.2 Amphibians

Of the eight species of amphibians known to occur in Alaska (MacDonald 2003), only the wood frog inhabits the Refuge. In the summer of 2001, a pilot study began monitoring wood frogs for malformations at three sites near Galena, Alaska. The goal was to collect a minimum of 50 froglets, young metamorphosed frogs before their first hibernation, and examine them for deformities. This project has since been incorporated into the Refuge's Inventory and Monitoring (I&M) Plan.

3.3.2.3 Birds

The numerous rivers and creeks of the Refuge provide riparian, wetland, and upland habitats that support abundant bird life. Nearly 150 bird species have been recorded on the Refuge, and 104 are thought to breed (appendix I); of these, 22 species are hardy enough to over-winter. Grouse, Owls, Woodpeckers, Chickadees, Gray Jays, Ravens, and Redpolls are year-round residents of the Refuge. The Refuge was established in part to protect the vast wetland complex in the Northern Unit Innoko and the floodplain of the Koyukuk and lower Nowitna rivers. These are important to waterfowl during many life stages. Wetland habitats also support a diversity of breeding land and water birds, including several species of conservation concern.

Three Breeding Bird Survey routes and three Off-Road Point Counts are conducted annually on or adjacent to the Refuge as part of the I&M Plan. Basic inventory work is still being conducted to update species lists. Species found in subalpine and alpine portions of the Refuge are probably underrepresented on bird lists.

Several thousand White-fronted **geese** and several hundred Canada geese nest and molt on the Refuge each summer. Annual (aerial) molting and (river-float trip) production surveys are conducted on portions of the Refuge. Extensive research on the nesting ecology and migratory patterns of interior nesting White-fronted geese have been conducted on the Refuge (Spindler and Hans 2005). White-fronted geese have been captured and banded on the refuge for survival rate analysis, but banding efforts ceased in 2001 in favor banding on the Southern Unit Innoko Refuge—where more geese can be captured in a cost effective manner. Recent analyses of survival data have revealed that interior Alaska White-fronted geese have a lower survival rate than other mid-continent white-fronted populations (Schmutz 2008).

Canada geese are less abundant than White-fronted geese but also breed and molt on the Refuge. Both species of geese are important subsistence harvested species, particularly during the spring season.

The Koyukuk contains habitat for both **Trumpeter and Tundra swans,** and a recent research project indicates 50 percent of the nesting swans on the Koyukuk are Tundra swans *(Cygnus columbianus columbianus)*, 20 percent of nesting swans on the Northern Unit Innoko are Tundra swans, and nesting swans on the Nowitna are 100 percent Trumpeter swans *(Cygnus buccinator)* (Bryant et al. 2007*)*. Tundra swans may be hunted statewide during spring and fall seasons, but Trumpeter swans are fully protected and remain closed to subsistence hunting. The two species are very similar in appearance and are difficult to identify on the wing.

Annual trend surveys of swans are conducted on the Refuge as part of the I&M Plan. Every five years, a refuge-wide census is flown as part of the statewide Trumpeter Swan Census. Both the census and trend surveys continue to show a steadily increasing swan population.

Duck abundance on the Refuge is currently monitored using the aerial duck breeding pair survey conducted by the Service's Division of Migratory Birds in Juneau. It should be noted

that the estimates apply to the entire Koyukuk stratum, of which Koyukuk is only a part. A comparison of the breeding pair estimates for the Koyukuk stratum to estimates of adults summering on the Refuge (based on 1990–1993 brood survey extrapolations) suggested that depending on the year, the Koyukuk represented approximately 36–65 percent of the ducks estimated for the entire Koyukuk stratum. The May 2006 estimated breeding duck population in the Koyukuk Stratum was 191,068 ducks. Using the percentages given, the calculated mean estimated population for Koyukuk was 68,785–124,194. These figures are up slightly from those seen in the past six years and are above the July post-breeding estimates of 62,000–117,000 presented by Saperstein (1997).

The Nowitna comprises less than 10 percent of the aerial duck breeding pair survey of the Tanana-Kuskokwim stratum conducted by the Service's Division of Migratory Birds in Juneau.

Duck production surveys were conducted on the Refuge from 1983 through 1992, and were analyzed by Saperstein (1996) in a report entitled *A summary of ten years of duck production surveys, Nowitna National Wildlife Refuge, Alaska, 1983–1992*. Saperstein found highly variable numbers of ducks and production of offspring was recorded in the early 1990s, with estimates of adult ducks ranging from 5,000 to 167,000.

In addition to the annual banding project at Willow Lake on the Koyukuk, ducks have also been banded on the Northern Unit Innoko as part of the statewide avian influenza monitoring project. Northern Pintails are the target species with a desired quota of 200 birds for each banding project. Ducks have been banded annually on the Koyukuk since 1989, and since 2006 on the Northern Unit Innoko. Results from these projects are reported in the I&M Plan (appendix C).

A number of **marsh and water birds** are commonly observed on the Refuge, including Common, Pacific, and Red-throated loons; Red-necked and Horned grebes; and Sandhill cranes. Yellow-billed loons are occasionally observed. Past duck production surveys indicate that Red-necked grebes, Common loons, and Sandhill cranes are the most common marsh and water bird species.

The following **shorebird species** are commonly observed on the Refuge: Lesser and Greater yellowlegs, Arctic tern, Glaucous gulls, Bonaparte's gulls, Mew gulls, Herring gulls, Long-tailed jaegar, Semipalmated plover, Common snipe, Spotted sandpiper, Least sandpiper, Pectoral sandpiper, Solitary sandpiper, Northern phalarope, Hudsonian godwit, and Whimbrel.

Gallinaceous birds (heavy-bodied, ground-feeding domestic or game birds) such as Ruffed and Spruce grouse are common in wooded habitats, while tundra and shrub habitats support Willow ptarmigan. Sharp-tailed grouse have also been infrequently observed.

The Refuge supports a diversity of **raptor species**, including Rough-legged hawks, Merlin, Sharp-shinned hawks, Northern harriers, Red-tailed hawks, Goshawks, Ospreys, Great horned owls, Great grey owls, Boreal owls, Northern hawk owls, American peregrine falcons, and Bald and Golden eagles. Raptors are generally sensitive to disturbance and serve as important indicator species.

Peregrine falcon surveys have been conducted periodically on the Yukon River between Ruby and Kaltag and on the Koyukuk River above the village of Koyukuk. The Service's Endangered Species Office conducted the survey (as part of a larger survey of the Yukon River) between 1979 and 1991. Refuge staff conducted partial surveys in 1992–1994. In 2000, a thorough Peregrine survey between Ruby and Tabernacle was conducted.

Beginning in 2001, surveys have been conducted annually on the Yukon River from just above Ruby to Galena. Presence of adults and nesting information is documented.

The rattling calls of Belted **kingfisher** can be heard along many creeks and rivers on the Refuge. Less common, but still occasionally seen and heard, are the year-round **woodpecker species**: Black-backed, Three-toed, Downy, and Hairy; and the migratory Northern flicker. Diverse wetland and terrestrial habitats on the Refuge support close to 50 species of **passerines** (the perching birds that are characterized by having four toes, three directed forward and one backward). The most common riparian **songbirds** are the Northern waterthrush, Alder flycatcher, Swainson's thrush, Yellow warbler, Blackpoll warbler, and Fox sparrow. Several species that breed on the Refuge are considered priority species for conservation in the northwest interior forest region. These included the Olive-sided flycatcher, Gray-cheeked thrush, Blackpoll warbler, and Rusty blackbird (Boreal Partners in Flight Working Group 2006). Year-round resident songbirds include Black-capped and Boreal chickadee, Gray jay, Common raven, Common and Hoary redpoll, Pine grosbeak, and White-winged crossbill.

3.3.2.4 Mammals

The Refuge has 36 species of mammals either known or suspected to occur on the Refuge (appendix I). This includes the musk ox, normally a species found along the Bering Sea and Arctic Ocean coasts. Musk ox is commonly seen along the continental divide in the northwest corner of Koyukuk. Three have been shot along the Kateel and Yukon rivers in the past five years. Moose occur in high densities on portions of Koyukuk. The Galena Mountain caribou herd commonly uses Koyukuk and periodically, large numbers of the Western Arctic herd use the Refuge during winter. Both black and brown bears are found on the Refuge. Many furbearers are common to abundant.

The Refuge contains an abundance of **moose** and large areas of excellent moose habitat. The Koyukuk River floodplain is excellent year-round habitat and contains high densities (3–10 moose per square mile) of moose from the mouth of the river all the way to the mouth of the Hogatza River. Kaiyuh Flats has a much lower density of moose (less than 1.0 per square mile), and the floodplain of the Nowitna has a moderate (1–3 moose per square mile) density of moose, while the rest of the Refuge is considered low density. The Koyukuk and Northern Unit Innoko supports 8,000–10,000 moose, and the Nowitna has between 2000 and 4000 moose. Harvest of moose from the Refuge is extremely important to both locals and non-locals. Several hundred hunters access the Refuge in September for the fall hunt. A hunter check station is manned annually on the Koyukuk River by the Alaska Department of Fish and Game, and the Service administers a check station at the mouth of the Nowitna River each fall.

Moose surveys are a big portion of the refuge inventory and monitoring program. Trend count surveys are conducted annually over 1,260 square miles of Refuge. Some of these trend count areas have been surveyed annually since the early 1980s. In addition to these trend surveys, periodic population estimates are also conducted using the Geo-Spatial Population Estimator technique. Twinning surveys are conducted annually in the spring. A research project involving radio-telemetry, investigating calf performance on differing winter ranges is also currently ongoing.

Two **caribou** herds normally occur on the Koyukuk and Northern Unit Innoko: the Galena Mountain herd (GMH) and the Western Arctic herd (WAH). The GMH is a small resident herd of approximately 150 animals that winter north of Galena and calve east of the Koyukuk in the western Kokrines Hills. The WAH is currently estimated at about 500,000 caribou. Portions of

the WAH winter on northern and western sections of the Koyukuk; but in the winters of 1989–1990, 1990–1991, 1992–1993, and 1998–1999, WAH caribou wintered southeast of the Koyukuk River from the mouth of the Koyukuk River, northeast to the village of Hughes. The Galena Mountain herd currently contains several radio-collared individuals and monthly radio-tracking flights are part of the inventory and monitoring program of the Refuge.

Both **black and grizzly bear** inhabit the Refuge. Black bear are abundant in the forested lowlands. Estimates of bear numbers on the Refuge are not available, primarily do the expense involved in censusing the species. Previous research on moose indicated that black bear were the most important predator of moose calves on the Koyukuk (Osborne et al. 1991). Black bear hunting pressure is low, but some traditional hunting activity occurs in the late fall when hunters inspect known den sites for black bear. Bear meat is considered an important traditional food locally. Information from village residents and incidental observations suggests that black bear may be declining in abundance while grizzly bear abundance may be increasing. Sow grizzlies with cubs have been observed on the Koyukuk in recent years by staff. Grizzlies are common in the hills surrounding the Refuge and use the salmon spawning rivers as feeding areas in the fall. Grizzly and black bear are often observed during moose twinning surveys hunting and killing moose calves.

Besides black and brown bear, the Refuge supports a wide variety of other carnivores (see appendix I for a complete list). Unlike many refuges and parks outside of Alaska, natural predator-prey relationships are intact within the Refuge. **Wolf** density on the Refuge is periodically estimated using the Sample Unit Population Estimator technique (Becker et al. 1998). Annually, all incidental observations of wolves are recorded, and during the spring, efforts are made to track and enumerate packs on the Refuge. These techniques are incorporated into the I&M Plan. Wolves are important as an integral part of the natural ecosystem, as a competitor with humans for a subsistence food source (moose), and as a valued furbearer. There is considerable local public interest regarding the number and location of wolf packs. Because of the high numbers of moose on Koyukuk, there are also high densities of wolves. The wolf density for Koyukuk was calculated to be 13 wolves per 1,000 square kilometers in spring of 2000, and the density of wolves on the Nowitna was 5 wolves per 1000 square kilometers in the spring of 2004 (Scotton 2004).

The abundance and distribution of **lynx** populations are affected primarily by natural cycles of their primary food source—the snowshoe hare (see the subsequent discussion of snowshoe hare). Based on harvest data and comments from area trappers, Stout (2004) identified peaks in the lynx population cycle in 1990–1991 and 2000–2001. If trapping records accurately portray the population cycles, the population was at its lowest point during the winter of 1995–1996 (Stout 2004). The time between population highs in GMU 21 appeared to be in time with the typical 10-year cycle of snowshoe hare and lynx. This is in contrast to eastern interior Alaska, where snowshoe hare and lynx numbers appear to have increased during the winters of 1990–1991 and 1991–1992, then again during the winters of 1997–1998 and 1998–1999, earlier than expected (Gardner 2001).

A study on Nowitna found that lynx were more abundant in an area that had burned 25 to 27 years previous than in a mature (greater than 100-year-old) needleleaf forest or an area that had burned 6–8 years previously. The study also found that ridges were favored travel locations by lynx. The moderate-aged, burned-over area and ridges also corresponded to areas with the greatest amount of brush cover, a preferred habitat for snowshoe hares (Johnson et al. 1995).

Wolverine are found throughout all of the Refuge. Incidental winter observations indicate that wolverine may be more locally abundant in the hilly regions of the Refuge than in other areas. Wolverine tracks are a common sight during wolf surveys and several suspected den sites have been observed incidentally.

Marten are found throughout the Refuge where suitable habitat exists. Incidental winter observations indicate that tracks are abundant in both open and closed needleleaf forest areas. A radio-telemetry study conducted on Nowitna looked at marten use of areas impacted by wildfire. While the study could not account for severity of the fires, the study revealed that marten were much more abundant in a a burned area 6–8 years old than a burned area 25–27 years old, but less abundant than in mature (greater than 100-year-old) needleleaf forests (Johnson et al. 1995). Marten are an important trapping species in the region; however, their importance has probably diminished substantially compared to the early 1980s when a large number of households participated in trapping and derived significant portions of their household incomes from trapping.

River otter and mink are common throughout the Refuge. These species are not specifically targeted by many trappers, but they are taken in low numbers incidentally. Population level information is lacking, but both species appear to be abundant and healthy based on tracks and inspection of carcasses from trapped animals.

Red fox and coyote appear to be common and widely distributed throughout most of the Refuge. Based on track observations, their numbers can fluctuate dramatically annually. Coyotes are present on Koyukuk and are probably occasionally present on the other two refuges. Two have been observed from the air and one was trapped near Galena during the 2007–2008 trapping season. Given the abundance of wolves on the Refuge, it is unlikely that a large coyote population will become established any time soon.

The smallest carnivore on the Refuge, and the smallest member of the carnivore order, is the **least weasel**. The least weasel preys primarily on lemmings and voles, but has been known to take small hare as well (Fagerstone 1987); therefore, cover and abundant prey are the primary driving factors behind the abundance and distribution of least weasels on the Refuge.

Beaver are abundant on the Refuge and are important ecological landscapers and furbearers. They are trapped by local residents for food and fur and can be a significant component in the diet of wolves, particularly during snow-free periods (Peterson 1977). Beaver play a large role in shaping the hydrologic features and habitats of the Refuge. Their activities increase habitat diversity by changing flow patterns and creating impoundments where lake habitats develop. Beaver also influence the structure and composition of terrestrial vegetation by foraging on shrubs and felling trees. Beaver dams can restrict fish movement during periods of low flow. This has generated concern about the disruption of normal fish movements (Andersen and Fleener 2001). Though dams may restrict fish movement at times, beaver ponds provide stable rearing habitat for juvenile fish (Snodgrass and Meffe 1999, Brown and Fleener 2001). In the Black River drainage of interior Alaska, Brown and Fleener (2001) found that juvenile northern pike, humpback whitefish, least cisco, and broad whitefish were found only in habitats created by beaver dams, while adults were found in both these and flowing water habitats. They also found that relative fish abundance was greater in lake habitats, and seasonal high flows provided opportunities for fish to move over beaver dams. Older, more stable beaver ponds were found to provide high quality breeding habitat for wood frogs (Stevens et al. 2006).

Beaver populations on the Refuge are monitored with trend area fall cache surveys as outlined in the I&M Plan. Densities have generally increased since the early 1990s on the Refuge. The Northern Unit Innoko contains the highest concentrations, where one township contained at least 145 active caches during the fall of 2005. Beaver are still trapped for their furs, and the meat is frequently used for human food, dog food, and trapping bait. Overall harvests are probably substantially lower than 20 years ago.

Muskrat is another furbearer that is important to some trappers. Muskrats were reportedly much more abundant in the region in the 1950s through the 1970s than they are now. Muskrats were commonly shot in the spring for their furs and for food. A few hunters and trappers pursue them in the springtime, but abundance of muskrats is generally low based on aerial pushup observations. Reasons for the low numbers of muskrat on the Refuge are unknown and have not been investigated.

While 15 species of **voles, lemmings, and mice** are known or suspected to occur (appendix I), little is known about the distribution and abundance of small mammal species that occur on the Refuge complex. Lehmkuhl (2000) studied yellow-cheeked voles on Koyukuk and estimated densities of yellow-cheeked voles ranging from 13 per hectare to as high as 143 per hectare. Small and medium-size mammals such as voles and snowshoe hares are the prey base for a wide variety of avian and mammalian predators. Krebs (2001) found that, in terms of biomass, snowshoe hares, squirrels, mice, and voles comprised a much greater percentage of herbivore biomass than moose in the Kluane ecosystem of the Yukon Territory. A similar relationship probably exists on large portions of this Refuge. Foraging, seed caching, and fertilization through fecal deposition by these herbivores also shapes their habitat, but the effects of their dietary habits on the ecosystem are poorly understood.

Yellow-cheek voles form colonies in burned areas in the boreal forest but are not commonly seen in high densities in undisturbed habitat. In terms of biomass, black spruce habitat supported more yellow-cheeked voles (approximately 4.5 pounds per acre) than upland spruce-birch forest (Rexstad 2003). This estimate of biomass per unit area is roughly equivalent to biomass estimates of moose in the Tanana River floodplain (Flora 2002), again emphasizing the importance of small mammals as a prey base and the role of fire in creating habitat and species diversity.

Snowshoe hare are an integral part of the boreal ecosystem. Hare population densities are cyclical across boreal North America over a period of 8–11 years (Keith 1963, Krebs et al. 1986, Keith 1990), with amplitudes of 5- to 25-fold (Hodges 2000). Hares are an important food item for a wide variety of terrestrial and avian predators (Keith 1990, Hodges 2000), and hare densities can greatly influence production and recruitment of a variety of species; the best known of these is lynx (Keith 1963, Brand and Keith 1979). Hare densities are also positively correlated with other species such as spruce grouse, willow ptarmigan, and arctic ground squirrel (Boutin et al. 1995). Great-horned owl and northern goshawk production and densities are also strongly influenced by hare density (McInvaille and Keith 1974, Keith et al. 1977, Boutin et al. 1995, McIntyre 1995). Other species, such as wolves, red fox, marten, and red-tailed hawks, may be less dependent on hares but likely use increases during cyclic highs (Wolff 1980, Todd et al. 1981, Carbyn 1987).

In North America, the order of insectivores is represented by two families, only one of which is found in Alaska. Shrews are the smallest mammals in the world. They are characterized by having long pointed snouts, short velvet-like fur, minute black bead-like eyes, and short but regular type legs (Banfield 1974). Projects on Koyukuk and Nowitna have confirmed the

presence of five species of shrews on the Refuge—common shrew, dusky shrew, tundra shrew, pigmy shrew, and tiny shrew (appendix I).

3.3.2.5 Threatened, Endangered, and Sensitive Wildlife

At this time, there are no federally listed Threatened, Endangered, or Sensitive plants or animals on the Refuge. The American race of the peregrine falcon was delisted (removed from the endangered species list) in 1999 but remains a (federal) Species of Concern (U.S. Fish and Wildlife Service 2002). Arctic peregrine falcons, which migrate through the Refuge, were delisted from threatened status in 1994.

The State has also identified species and subspecies of fish and wildlife native to Alaska that have entered a long-term decline in abundance or are vulnerable to a significant decline (Alaska Department of Fish and Game 2006). Vulnerability to decline includes low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance. On the Refuge, identified (State) Species of Special Concern include Peregrine falcon, Olive-sided flycatcher, Gray-checked thrush, Townsend's warbler, and Blackpoll warbler.

The Olive-sided flycatcher occurs in mature spruce forests associated with habitat edges, in burns, and in riparian areas. The Gray-cheeked thrush is found in a variety of habitats: willow and alder thickets in lowland, upland, and subalpine areas; upland and riparian deciduous forests; needleleaf forests; and needleleaf-deciduous woodlands. Townsend's warblers select mature needleleaf forests for nesting; white spruce appears to be an important component to site selection. Blackpoll warblers select for a variety of habitats but are commonly associated with tall shrubs in riparian areas, needleleaf forests, deciduous forests, and woodlands.

3.3.3 Concerns Regarding Fish, Wildlife, and their Habitats

3.3.3.1 Increased Fishing Pressure

The potential for increased fishing pressure on existing fisheries may affect population size and structure of several species found on the Refuge. In recent years, the Nowitna River and Kaiyuh Flats have become popular destinations for guided anglers who target northern pike. Although these anglers target trophy fish with little harvest, the combination of subsistence harvest, sport harvest, and post-capture mortality in the sport fishery could affect the status of the population. The combination of subsistence and commercial harvest may also affect salmon stocks. Likewise, the combination of subsistence fishing and emerging commercial markets has the potential to affect whitefish populations. See section 4.2.2.2 for a discussion of environmental consequences to fish, and sections 2.1.1 (Objectives 1, 2, 3, and 4) and 2.1.7 (Objectives 2, 3, 5, and 6) for a discussion of fish goals and objectives.

3.3.3.2 Off-refuge Harvest of Refuge Whitefish and Salmon Stocks

Main channel Yukon River mixed stock commercial and subsistence fishing may have an effect on the population size and structure of salmon and whitefish that spawn on the Refuge. Because there are no available means to rapidly identify particular stocks of these species, refuge stocks could be disproportionately harvested. Disproportionate harvest could be especially detrimental to small stocks that pass through fisheries during a short time frame of intense fishing activity. The by-catch of salmon in Bering Sea and Gulf of Alaska ground fish fisheries may also affect refuge salmon stocks.

3.3.3.3 Development of Inholdings and Lands Adjacent to the Refuge

Private lands within and outside the Refuge have the potential to be developed for residential, mineral, sport fishing, and remote tourism access. These developments may lead to fragmented habitats, degraded water quality, reduced in-stream flows, altered water tables, increased pressure on fishery resources, and increased conflicts with local users. Coordinated planning efforts among agencies and private land owners will help decrease inconsistencies.

3.3.3.4 Alteration of Wild Salmon Stocks Caused by Artificial Enhancement

During recent times, several stocks of salmon in the Yukon River have become depressed to where management actions have reduced fishing opportunities by restricting fishing periods, areas, or gear. With insufficient numbers of fish for harvest and escapement, enhancement could, at some future date, become a consideration for rebuilding the stocks. Enhancement could develop large populations of particular stocks that could be heavily exploited. Such exploitation of enhanced stocks could lead to pressure on more vulnerable smaller stocks. If carefully planned and implemented under both State and Service protocols, enhancement could supplement wild salmon production and safely increase salmon harvests.

3.3.3.5 Past and Current Off-Refuge Mining Activities

Placer and hard rock mining activities can introduce excessive amounts of sediment and other contaminants to streams, causing degraded fish habitat. Historic placer mining activities undoubtedly caused increased levels of turbidity and sediment transport in some streams, but there are insufficient data available to determine the extent that mining practices may have had or will have on refuge fish populations and their habitats. However, current mining technology and State and federal regulations have substantially reduced potential pollution. Water quality monitoring of refuge streams will identify upstream disturbances that may affect refuge fishery resources.

Mining activities may have introduced contaminants to streams, causing degradation in water quality and fish habitat. Placer mining activity on tributaries of the Hogatza River has the potential to cause increased levels of turbidity and sediment transport. Another major concern is leaching of heavy metals and chemicals such as cyanide into the water.

3.3.3.6 Climate Change

Although predicting the effects that climate change will have on Refuge fishery resources is difficult, this phenomena will undoubtedly require new approaches to research and management. Not only will new approaches be needed to understand the biological responses by fish to climate change, there will also be a need to understand changes in access and use patterns by all user groups. Future approaches must also consider modifications to transportation methods and corridors that may threaten resources formerly not considered at risk. Research and management approaches must keep pace with the effects of emerging technologies and their effects on fishery resources on the Refuge.

Long-term changes in weather patterns have become issues of interest and concern both among scientists and residents of northern communities where changes have been most pronounced. Variations in weather patterns can significantly affect wildlife and plant communities, as well as human residents who depend upon their environment for food and travel. Overall, the climate in Alaska has warmed by about four degrees Fahrenheit since the mid-1950s, including a seven-degree Fahrenheit increase during the winter in interior Alaska (Parson et al. 2001). Climate models project that the greatest warming will continue to occur

in the Arctic region (Parson et al. 2001). A warming climate will have numerous effects on habitat, hydrology, and species occurrence that could fundamentally change the boreal forest as we know it (Hinzman et al. 2005).

The Refuge has worked with researchers at the University of Alaska Fairbanks (UAF) to examine historic local weather patterns using data collected at area villages for the U.S. Weather Bureau. Data includes daily temperature extremes and precipitation and has been documented for more than 80 years in some villages. At Galena, weather records date back to 1942, and analysis has shown some interesting trends and patterns over the past 65 years. Many of these observations corroborate perceptions of local elders. Below are some of the changes that are evident from weather data and local observation.

- The cold season (October–March) has shown the greatest warming. Extreme cold events have decreased in frequency, duration, and severity.
- Total winter snowfall shows an increase, although moisture contribution does not, suggesting that the snow is drier and less compact. Snow comes later in the winter (January–March).
- Temperatures above freezing are more common in March and April. In some years, this results in an early thaw. However, late spring frosts continue, and the start of the growing season (consecutive frost-free days) has not changed.
- River breakup is less dramatic, with thinner ice sheets and less frequent flooding.
- Summer temperatures have remained fairly stable, with a slight cooling trend in daily lows.
- Total annual precipitation has remained fairly stable. Most occurs in the warm season (June–September) as rain. June and September precipitation has increased, while July and August precipitation has decreased.
- Warm rainy weather typical of late August extends later into September in some years.
- Despite an increase in the frequency of fall temperatures above freezing (September–October), the first fall frost is coming earlier and the Galena growing season is getting shorter.
- More October precipitation occurs as rain instead of snow. Freeze-up is occurring later, and conditions are less predictable, causing concerns about ice thickness and travel safety.

Climate change research predicts that the boreal region will experience a decline in wetlands, an increased fire frequency and intensity, shifts in the distribution and composition of plant communities, changes in phenology, changes in the ranges and breeding behavior of wildlife species, increased likelihood for invasive plant establishment, and increased possibility of wildlife disease and insect outbreaks. These changes in habitat and wildlife due to climate warming will, in turn, affect the arctic and subarctic people who rely on natural resources for food, livelihood, and cultural identity.

Changes in wetlands are of particular concern due to their extent on the Refuge, contribution to biodiversity, and importance to numerous fish and wildlife species. Interior Alaska receives relatively little precipitation, and the abundant wetlands result largely from short summers with low evapotranspiration and an impermeable permafrost layer, which prevents infiltration and impedes drainage of the upper unfrozen layer (Ford and Bedford 1987). Climate warming

has already caused noticeable widespread melting of permafrost in the boreal region (Osterkamp and Romanovsky 1999, Jorgenson et al. 2001) and increased evapotranspiration, resulting in shallower, more nutrient-rich wetlands (Rouse et al. 1997, Klein et al. 2005, Smith et al. 2005). These conditions also contribute to an increase in floating mat vegetation, which results in loss of surface water. Over the long-term, this insulates the soil and can lead to permafrost re-development. The long-term effects of climate change on lake system dynamics are unclear.

Research and monitoring efforts help us understand the extent of climate-related changes on the Refuge. Since changes also occur on a much broader scale than the Refuge, it is most appropriate to participate in larger, landscape-level efforts to monitor climate change and its effects on wildlife and habitats. Though there may be little that the Refuge can do to mitigate these changes, awareness of long-term climate change effects may lead to changes in management strategies. Ongoing communication with resource users regarding environmental changes and discussion of potential management approaches is vital in developing strategies to deal with the effects of climate change.

3.3.3.7 Invasive Species

Although few non-native plant species have been identified within the Refuge, there is concern that the diversity of invasive species and number of sites may expand. Lambsquarter and foxtail were discovered recently on the Nowitna. These species readily invade open, disturbed sites such as sandbars and gravel bars along rivers. Recent burns can provide similar habitat. Individual plants can be removed by mechanical means (pulling or cutting); several attempts may be needed for eradication; and spread is accelerated when seeds are moved by wind and water. Finding all occurrences of invasive species on the Refuge may be impossible.

3.3.3.8 Forest Defoliators

Invasive, non-native insects (e.g., larch sawfly and eastern larch beetle) have already negatively affected larch in the region (Rozell 2007), particularly in the Nowitna River corridor. Spruce budworms, along with leaf miners, are also of concern for their ability to alter plant community composition. Insect induced changes in plant communities, potentially accelerated by climate changes, could significantly affect wildlife communities on the Refuge. Native leaf blotch miners (*Phyllocnistis populiella* and *P. ontario*) affect conifers, aspen, cottonwood, paper birch, and green alder. Willow leaf miners (*Micrurapteryx salicifoliella*) attack all of the willow species found on the Refuge except feltleaf willow. Repeated heavy attacks on the same tree or shrub generally cause reduced growth and branch dieback and may cause mortality (Holsten et al. 2001).

The spruce beetle *(Dendroctonus rufipennis)* is a bark beetle that attacks white spruce and can cause extensive tree mortality (Holsten et al. 2001). Bark beetles bore through the outer bark and feed and breed in the phloem. If the phloem is girdled, the tree will die. Small populations of beetles are usually present in spruce forests and are kept in check by parasites and predators of the insect. However, epidemics may be caused when an abundance of breeding material is present, often accompanied by an extremely dry summer. Beetles attack and breed in fresh wind thrown trees, felled trees, injured trees, and large diameter logging slash. Proper treatment of logging slash to minimize potential for spruce beetle outbreaks is a condition of the Refuge Special Use Logging Permits.

3.3.3.9 Moose

Moose are a critically important subsistence species to local residents and are widely sought after by sport hunters. Concern was expressed during public scoping for revision of this Plan about competition with non-local hunters and predators. See section 1.8.1 in chapter 1 for additional discussion of this issue.

3.3.3.10 Predator Control

Moderate densities of moose on the Refuge, coupled with local interest in predator control, may contribute to increased pressure on the Refuge to consider a predator control program in the future. For additional information about predator management on Alaska National Wildlife Refuges, see appendix E.

3.4 Human Environment

3.4.1 Area History

3.4.1.1 Prehistory

The archaeology of interior Alaska in general is not well known, but a broad outline can be sketched. Most research has focused on the earliest inhabitants. By about 9000 BC, the unglaciated areas of central Alaska, including the refuge region, was occupied by people belonging to several archaeological traditions, including the Northwest microblade complex, Nenana Complex, Denali Complex, Chindadn, and Sluiceway, and people closely related to the East Siberian groups of the same period. Many authorities consider most of these traditions to be variations of a single Paleo-Arctic tradition (Clark 1981, Clark 2001, Dumond 2001, Holmes 2001).

These people used a blade and microblade technology, presumably in conjunction with an extensive kit of bone, antler, and wooden tools. A preferred material for blades and microblades was obsidian. The primary source of obsidian for interior Alaska was the Batza Tena site in the northeast corner of the Koyukuk (Clark and Clark, 1993). Obsidian from Batza Tena has been found in archaeological sites throughout Alaska and portions of northern Canada.

As the glaciers retreated, lines of communication were opened to the south and east. The previously easy routes to the west were blocked by the encroaching Arctic Ocean and Bering Sea. In this period, there are indications of contact and perhaps an amalgamation of the Siberian-related cultures and the Paleo-Indian cultures that had been developing south of the continental ice sheets. The Mesa site on the North Slope, and Spein Mountain in southwest Alaska, have been interpreted as a manifestation of the big-game hunting Paleo-Indian tradition, with roots in the Great Plains.

The Northern Archaic tradition began about 6,000 years ago with clear antecedents in the Paleo-Arctic tradition. The tradition is defined by the presence of side notched points in tool assemblages. In addition, Northern Archaic people used leaf-shaped spear points; large bifaces; a variety of end scrapers, choppers and hide scrapers; and notched stone net sinkers. Net sinkers signal a significant shift in subsistence from land based hunting to a mixed hunting and fishing economy that incorporated the rich fish resources available in lakes and rivers. The presence or absence of microblades in Northern Archaic sites remains a debated point of northern archaeology. Microblades are rare from most sites dating after this time, but they never totally disappear from the record.

The Northern Archaic tradition lasted until about 2,000 years ago. It is generally assumed to be ancestral to the more recent cultures of the area. This later prehistoric period, up until European contact, is characterized by small, tapered-stem projectile points, ground-stone hide and wood working tools, bone implements, and limited use of copper. Sites are larger than those of the earlier Northern Archaic and Paleo-Arctic peoples, and contain semi-subterranean houses and cache pits. There is, however, substantial diversity in the sites of the later period, and the advent of sites that can be described as clearly being in the "Athabascan tradition" is highly variable in time. Much work remains to be done to clarify and explain what have been described as somewhat "refractory" (ambiguous) data (Clark 1981).

3.4.1.2 Ethnography

The majority of the Koyukuk and Northern Unit Innoko lie within the territory of the Koyukon Athabascan Indians; the Northern Unit Innoko falls into the Lower Yukon subdivision; while the Koyukuk falls into the Koyukuk River subdivision. In the 1987 Plan, the northwestern portion of the Koyukuk River was described as being within the territory traditionally inhabited by Eskimos; however, that area was sparsely populated, and the Eskimo population will not be discussed here. The Nowitna lies within the territory of the Upper Yukon subdivision. The Koyukon Athabascans depended heavily on the anadromous fish resources of the Yukon and Koyukuk Rivers and their major tributaries, along with moose, caribou, and a variety of other fish, small game, and—to a lesser extent—plant resources for their food source. They frequently occupied large semi-permanent villages and fish camps during the summers and dispersed from these into the tributary drainages for hunting and trapping in the fall and winter.

At the time of contact, it was estimated that the Lower Yukon Koyukon group numbered about 425 individuals, while the Koyukuk River Koyukon numbered something over 289 people, and the Upper Yukon Koyukon were at about 300 people. Koyukon and Upper Yukon groups were generally divided into small bands of less than 50 members that were based on a core of several matrilineal extended families and included some unrelated individuals. Band territories were fairly well defined and quite large, reaching as much as 50 to 75 miles across. In the Lower Yukon area, there was no clan development, and band areas were exploited by groups based on semi-sedentary villages. Communal property (most large game hunting areas, fowling areas, and berry picking areas) was present within most band territories, but other sites were seen as private or family property (beaver houses and ponds, other trapping areas, fishing sites, and bear dens) (Clark 1981).

There was no distinct developed political organization among the Koyukon, although individual leaders were recognized in some cases (most commonly, they were economically successful and often the owners of the best fishing, hunting, and trapping areas). The elders of a group might be called upon to decide on important matters, but this was not a structured process. The Koyukuk River Koyukon maintained friendly relations with the Upper Yukon group. However, the Koyukuk River and Upper Yukon Koyukon regarded the Lower Yukon Koyukon as hostile (Simeone 1982).

3.4.1.3 History

European presence in the Middle Yukon region began with Andrei Glazunov's exploration up the Unalakleet river and overland to the Yukon settlement of Ttutago in 1837 (deLaguna 2000). Declining sea otter populations had prompted the Russian-American company to seek new sources of fur on Alaska's Arctic coast and in the interior. In 1838, Petr Vasil'evich Malakhov of the Russian-American Company followed a similar route to Glazunov's. He found

a suitable location for a trading post near the mouth of the Nulato River. Despite tremendous impacts of the smallpox epidemic in Nulato, a post was established the following year. For the first several years, operation of the post was intermittent due to lack of food and periodic burning of the company's buildings by local Natives.

European trade goods had become available some years earlier through Yupik and Inupiaq Eskimo middlemen trading from the lower Yukon, Norton Sound, and the northwest coast (deLaguna 2000). In 1842, Lieutenant Lavrentii A. Zagoskin of the Russian Navy was sent to investigate the unknown trade routes by which much fur from the Nulato region was bypassing the post and reaching Kotzebue and thence Siberia. In 1843, Zagoskin led an exploration up the Koyukuk River as far as the Kateel River, where he discovered a well established trade network between the Koyukuk Indians and Malemiut Eskimos of Kotzebue Sound (deLaguna 2000). Zagoskin also led an expedition up the Yukon River to near the mouth of the Nowitna River. The party encountered a number of camps and settlements along the Yukon, as well as native traders from the upper Innoko River.

The establishment of the Hudson's Bay Company Post at Fort Yukon by Alexander Hunter Murray in 1847 provided competition for the Russians and reduced the importance of the Lower Yukon Koyukon as trade middlemen for the upriver Koyukon. The post was continuously operated until 1869 (Turck and Turck 1992). There was an important native trading site and settlement called Nowikakat at the mouth of the Nowitna River, which was visited by the explorers Whymper and Dall (from the Scientific Corps of the Western Union Telegraph Expedition) in 1867. At the time, Nowikakat was a substantial village of some 150 residents who were living in skin tents and tents made of commercial woven fabrics. The natives were equipped with English flintlocks, as opposed to percussion rifles which were obtained from the Russians (Simeone 1982). The first trading post in the immediate vicinity of the Nowitna was established in 1869 by Gregory Hakorcins (later changed to Kokrines), a Russian or Creole trader, at Fourteen Mile. Hakorcins subsequently moved his post to the area currently shown as Kokrines on the Yukon River. This move resulted in the move of the entire village (Hart 1981).

Unrest between native trade groups and the Russians, including periodic raids and attacks, was somewhat common in the region and culminated in the Nulato Massacre of 1851. This attack was one of a series of strikes made by the Koyukuk River people against the Lower Yukon Koyukon, likely the result of trade rivalry, and resulted in the deaths of over 50 people living in and around the trading post. Despite these difficulties, the Nulato post continued to serve as a profitable trading station until the Alaska Purchase in 1867.

The upper Koyukuk River area remained virtually unexplored by non-Natives until 1885 when Lieutenant Henry T. Allen was sent by the U.S. Army to investigate reports of a drop in prices paid for furs and to count the Native people. Gold prospectors followed Allen and by the late 1880s had begun what has been a long history of mining in the area (mainly upriver of the Koyukuk). The first ascent of the Koyukuk River by steamboat occurred in 1897, the same year a U.S. Post Office was established at Nulato. The first wood-powered paddle-wheeler had begun regular service on the Yukon in 1869. The cutting of cordwood for the steamboats provided some income to Natives living along the river. Gold was discovered near Ruby in 1907, beginning another substantial influx of outsiders to the area. Mining interests in the Ruby region were generally confined to the area west of the Nowitna (Hart 1981).

The construction of a military telegraph line along the north side of the Yukon River brought more Americans into the area just about the turn of the twentieth century. The posts were

located about 40 miles apart, resulting in a semi permanent Euro-American presence throughout the area. However, the line was virtually abandoned by about 1915 (Simeone 1982). Roadhouses remained, scattered along the Yukon at approximately 30-mile intervals to accommodate dog teams hauling mail and other winter travelers (Hart 1981). Wireless radio transmitters were installed at telegraph stations along the river in 1922, operated by the U.S. Army Signal Corps (Hart 1981).

Interest in gold mining had generally subsided by the 1920s, and numerous miners left the region upon being called up to fight in World War I (Hart 1981). Many of the remaining residents turned to trapping for income. A boom in fur prices in the 1920s and 1930s filled the river valleys with trappers, both Native and white. Many of the natives had begun to settle in communities that offered a store, school, and church. Missionaries had begun work in the region near the turn of the century, and several mission schools were well established by World War I. Changes in technology continued to affect life in the Koyukon Region, with airplanes and gas engines replacing dog team and paddle.

A long steady process of change for the Koyukon people was well underway. The shift from a semi-nomadic, subsistence oriented lifestyle to a community centered, sedentary lifestyle became more complete by 1956, by which time all of the Koyukon villages had a school (Turk and Turk 1992). Requirements for year-round school attendance had significant impacts on the culture and lifestyle. Prior to 1976, most communities did not have secondary schools, and older students were sent to boarding schools. Community infrastructures developed to accommodate increasing populations and changes in technology; airports, roads, housing developments, clinics, water, and sewer and electrical systems gradually became available in each village. The passage of the 1971 Alaska Native Claims Settlement Act (ANSCA) also had substantial impacts on the organization of tribes, and their relationship to the land. Despite all these changes, harvest of fish, game, and other resources remained vital components of the Koyukon economy and culture. When the Alaska National Interest Lands Conservation Act (ANILCA) became law in 1980, it contained language specifically supporting continued traditional and customary use on designated Federal lands. Contemporary life in the Koyukon region is a unique blend of modern culture along with subsistence practices and other lifestyle elements which differ surprisingly little from the days of first European contact.

A summary table of historic events is found in appendix J.

3.4.1.4 Archaeological and Historic Sites

The Koyukuk has 269 recorded historic and cultural sites. Of these, 128 are listed on the Alaska Heritage Resources Survey (AHRS) and most of these are archaeological sites. The non-AHRS sites include place names, historic sites, cabins, and other reported but unverified sites. The best known archaeological sites on the Koyukuk include Hahanudan Lake, the Batza Tena obsidian source on the Little Indian River, and the Nogahabara Sand Dunes. The sites at Hahanudan Lake represent an apparent intrusion of Ipiutak Eskimo peoples into an area presently occupied by Athabascans (Clark 1977). Artifacts from these sites are similar to those recovered from the Ipiutak type site at Point Hope. The sites around Little Indian River span a time up to 12,000 years and a wide diversity of cultures ranging from Paleo-Indian materials (fluted points) up through sites from the immediate pre-contact period (Clark and Clark 1993). This area accounts for over 75 of the AHRS sites listed for the Koyukuk. One site on the Nogahabara Dunes is a Pleistocene age site where over 260 biface and uniface tools, microblades, and preforms were recovered (Odess and Rasic 2007). Within the assemblage are microblade cores, lanceolate bifaces, and notched projectile points; tool types

previously thought to be characteristic of unrelated cultural traditions and archaeological complexes. Most artifacts were obsidian from Batza Tena and showed transport wear that demonstrates a high level of material conservation.

During later prehistoric periods, the question of the dynamics between coastally adapted (Norton, Ipiutak) people moving inland and their interactions, if any, with interior adapted people is of great interest. If more recent sites are found, they would provide information on the development and adaptations of Koyukon Athabascan culture. The history of the Koyukuk River is particularly poorly documented, and historic remains are an invaluable record of the early exploration and use of the refuge area.

The Northern Unit Innoko has about 175 recorded native place names but no recorded archaeological or historic sites, and nothing listed on the AHRS.

The Nowitna has 10 recorded sites, including two on the AHRS. Among these is Novikakat, a settlement and trade center situated at the mouth of the Nowitna River and visited by explorers Whymper and Dall (deLaguna 2000). No extensive work has been done at this site, and the present extent of the remains is unknown. Two other reported camp locations (Minkhotlyatno River Camp at the mouth of Big Creek, and Tsoonakeek'at on Junakaket Slough) may also have archaeological remains.

It is unlikely that these small and geographically restricted samples represent the true extent of the archaeological resources of the Refuge. It is probable that there are a substantial number of sites that have yet to be discovered. Since the area was ung1aciated during the late Pleistocene, it is entirely possible that other very early sites may be located within the Refuge. Due to the meandering nature of the streams of the area, many such sites may already have been destroyed or covered by natural causes. There is a high likelihood of finding recent sites on present stream banks, but older sites probably only remain on higher ground.

3.4.2 Population and Settlement Patterns

3.4.2.1 Overview[1]

The Refuge lies within the Yukon-Koyukuk Census Area (Figure 3-10), which covers over one-quarter of Alaska's landmass but is home to less than 5,900 people (Table 3-11). Three other national wildlife refuges are also located wholly or partially within the Census Area. Most of the Refuge, and most of the communities affected by refuge management, lie within the Koyukuk–Middle Yukon census sub-area. Galena is the largest community in the sub-area, with 675 residents.

Table 3-11. Population trends in the Yukon-Koyukuk Census Area in Alaska 1990–2020.

Yukon-Koyukuk Census Area - Alaska						
	Census		Estimate	Projections		
	1990	2000	2006	2010	2015	2020
Population	8,478	6,551	5,844	5,899	5,766	5,595

[1]Except where otherwise noted, this section is adapted from: Windisch-Cole, B. 2001: The Yukon-Koyukuk Census Area: A profile of rural Interior Alaska. *Alaska Economic Trends*, 21(2).

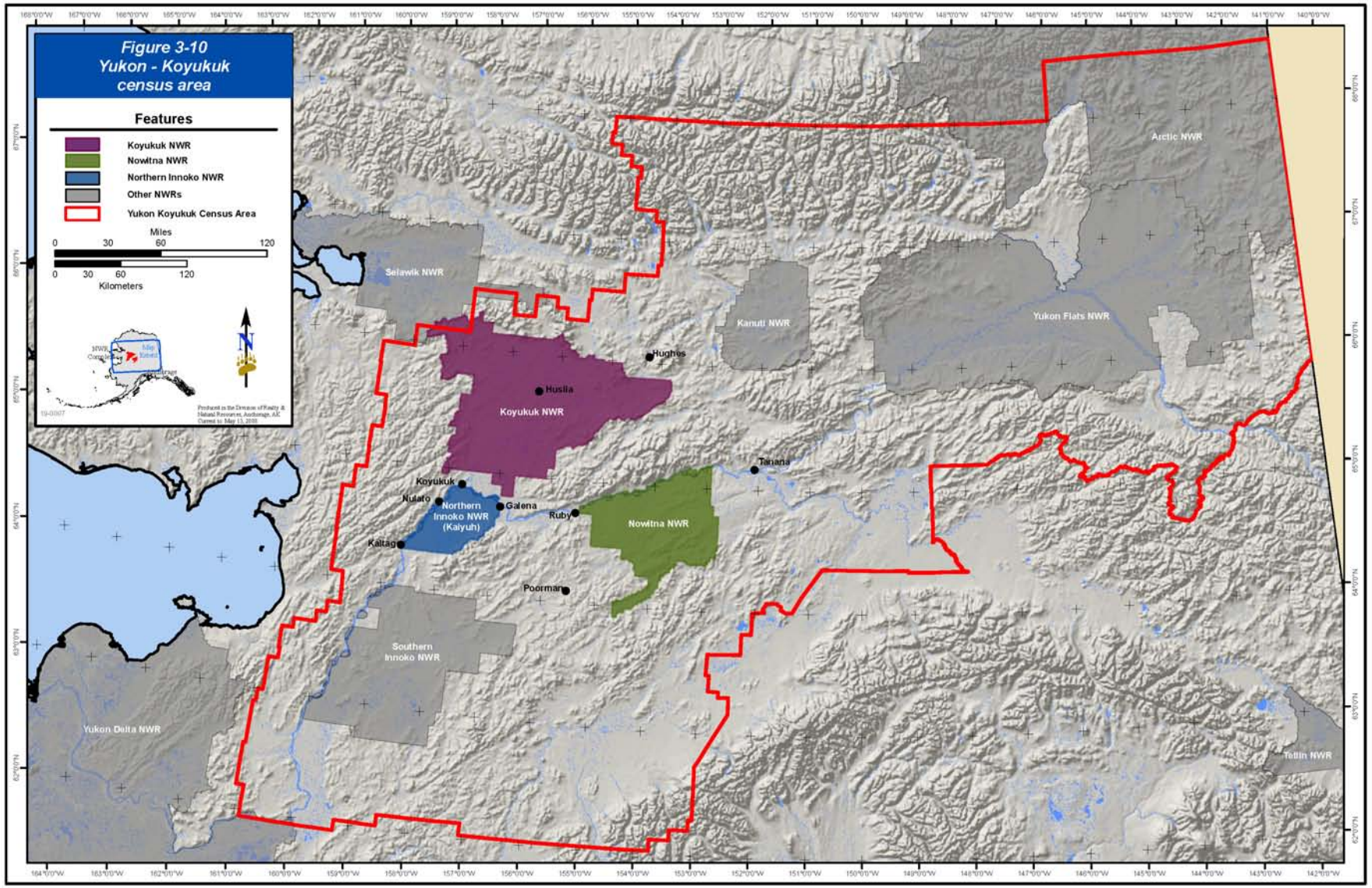


Figure 3-10. Yukon-Koyukuk census area

About 70 percent of the Yukon-Koyukuk Census Area population is Alaska Native. Forty-six percent of area residents are female, and the median age is 32. Males have a median age of 33. Roughly 74 percent of the adult population has at least a high school education, and 14 percent have completed a bachelor's or higher degree.

The Institute of Social and Economic Research (ISER) at the University of Alaska prepared a set of population projections for Alaska in the late-1980s (Goldsmith 1986) based on four different economic scenarios. The population in the Yukon-Koyukuk region was projected to grow between zero and 31 percent from 1986–2010. After a short period of growth, however, the populations of most communities in the region stabilized or began to decline. In 2000, there were just over 2,200 residents in the region—about 100 *fewer* than in 1980 (Table 3-12). Most of the reduced population is attributable to declines in Galena, which now has nearly 200 fewer residents than in 1990. Huslia is the only village to have had a substantial population increase since 1980 (Table 3-12). Current population projections suggest a continued but less dramatic decline for the Yukon-Koyukuk Census area (Palin et al. 2007) (Table 3-12).

Table 3-12. Population trends in the Koyukuk, Northern Unit Innoko, and Nowitna area communities.

COMMUNITY	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Galena	0	0	0	0	0	67	44	176	261	302	765	833	675
Hughes	0	0	0	0	45	0	32	49	69	85	73	54	78
Huslia	0	0	0	0	0	0	0	65	168	159	188	207	293
Kaltag	45	29	0	141	89	137	140	121	165	206	247	240	230
Koyukuk	150	174	0	121	124	143	106	79	128	124	98	126	101
Nulato	168	118	281	230	258	204	113	176	283	308	350	359	336
Ruby	0	0	0	0	128	132	138	132	179	145	197	170	188
Tanana	0	203	186	398	213	185	170	228	349	120	388	345	308
TOTAL	363	524	467	890	857	868	743	1,026	1,602	1,449	2,306	2,334	2,209

3.4.2.2 Principle Refuge-Affected Communities[2]

Residents of eight local villages rely most heavily on the Refuge for subsistence resources. These communities are Galena, Hughes, Huslia, Kaltag, Koyukuk, Nulato, Ruby, and Tanana (Figure 3-10). Galena is important as a regional service hub and population center, and also as the site of the refuge headquarters. Within the broader region, these eight communities are most likely to affect, and be affected by, Refuge management.

All of the villages are accessible by air or water only. No roads connect these villages with any other community or to Alaska's road system. All the villages are located on the bank of a major river: six are on the Yukon River, and two are on the Koyukuk River. Rivers are essential to local transportation—boats provide warm season transportation between villages and access to subsistence resources, and river barges deliver cargo during summer months. Snowmobile trails are established on the rivers for winter travel. Automobiles, snowmobiles, ATVs, and boats are used for local transportation within the village. State-owned, lighted gravel airstrips

[2]Except where otherwise noted, this section is adapted from the Alaska Community Database Online, provided by the Alaska Department of Commerce, Community, and Economic Development and accessed online at: www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm

provide year-round access (Galena has a paved airstrip). Supplies, services, and travel out of the region generally route through Fairbanks, the urban center of interior Alaska.

Galena

Galena is located on the north bank of the Yukon River, 45 miles east of Nulato and 270 air miles west of Fairbanks. It lies just north of the northeastern portion of the Northern Unit Innoko and is less than 10 miles south of the Koyukuk. Galena was established in 1918 near a fish camp called "Henry's Point" as a supply point for nearby lead ore mines. In 1920, Natives living 14 miles upriver at Louden began moving to Galena to sell wood to steamboats and to work hauling freight for the mines. A school was established in the mid-1920s, and a post office opened in 1932. Military presence at Galena began in 1941 with the construction of a runway and hangar adjacent to the civilian airport. In 1945, the community suffered a major flood. During the 1950s, military facilities at Galena and the nearby Campion Air Force Station were constructed in support of the 5072nd Air Base Group, headquartered at Elmendorf Air Force Base, Anchorage. The Air Force presence in Galena provided improvements to the airport and the local infrastructure and economic growth for the area. Due to another severe flood in 1971, a new community site was developed along side Alexander Lake, about 1.5 miles east of the original town site. City offices, the health clinic, schools, a store, and more than 150 homes were eventually constructed at "New Town," and a City government was formed. The Galena Air Base was placed in a caretaker status in 1993, following the end of the Cold War. It will be decommissioned in 2008. Some of the base facilities are currently being used by the Galena School District as a boarding school. Galena serves as the transportation, government, and commercial center for the western interior. Federal, state, city, school, and village government jobs dominate, but Galena has many other jobs in air transportation and retail businesses.

Hughes

The community of Hughes, on the east bank of the Koyukuk River, is surrounded by the Indian Mountains to the east, the Hatdolitna Mountains to the north, and Hughes Mountain directly west of the town. Hughes is about 210 miles northwest of Fairbanks, 65 miles northeast of Huslia, and 12 miles north of the Koyukuk. Hughes is the smallest of the communities near the Refuge with a population of 78 in 2000. There are strong social ties between the residents of Hughes and Allakaket, 75 miles up the Koyukuk River.

Traditionally, the Hughes area was used as a trade center between the Athabascan and Inupiaq Eskimo. In 1884, Roy Hughes prospected an area two miles upstream from the village, but according to the U.S. Geological Survey, the community was named in 1910 after New York Governor Charles Hughes. It served as a riverboat landing and supply port for the Indian River gold fields until 1915 when the local mining industry declined. The Hughes post office was established in 1942. An airstrip was built in the 1950s, a school in 1956, and a clinic in 1968. The city was incorporated in 1973. Local roads were built in 1974. A community-wide electric system was developed in 1981. In September 1994, flood waters destroyed and swept away nearly all of the community buildings, homes, and winter food caches. Residents rebuilt homes and facilities following the flood. River transportation is very important to Hughes, although barge service is not reliable due to shallow water. Most fuel and heavy freight is brought in by air.

Huslia

Huslia is the only community in the region that is located within (Koyukuk) Refuge boundaries. It is situated on the east bank of the Koyukuk River in the Koyukuk Lowland. The lands surrounding Huslia are generally low with numerous lakes, streams, and rivers. Roundabout Mountain is 12 miles southwest of Huslia on the opposite side of the Koyukuk River. The Huslia River flows east across the northern portion of the Koyukuk to its confluence with the Koyukuk River midway between Cutoff and Huslia. Because of its location, the subsistence activities of Huslia residents are centered on the Koyukuk.

The village of Huslia traces its roots to the Cutoff Trading Post, which was established in the 1920s about 4 miles north (16 river miles) of Huslia. In 1949, the community moved to the present site because the Cutoff location flooded frequently, and the ground was swampy. Huslia (originally spelled Huslee) was named after a local stream. The area had been used as a burial site since 1886, but by the time of the move, most of the old cemetery had been destroyed by bank erosion. In 1950, the first school was established, followed by a post office, airport, and road construction in 1952. At that time, families began to live year-round at Huslia. In 1960, a health clinic was constructed, and in 1963, hand-pumped water wells were installed. The city government was incorporated in 1969. Running water and indoor plumbing arrived in 1974. A new airstrip was constructed during the summer of 2000, and new homes have been built along the old airstrip. Cargo arrives by barge several times a year. Huslia is accessible by air year-round.

Koyukuk

The village of Koyukuk is located at the confluence of the Yukon and Koyukuk Rivers, directly across from Koyukuk Island and the Kaiyuh Flats, and about 10 miles south of the Koyukuk. Koyukuk is 290 miles west of Fairbanks and 30 miles west of Galena.

In 1867, Koyukuk became the site of a telegraph station when the military telegraph line was established on north side of the Yukon River. A trading post opened around 1880, just before the gold rush of 1884–1885. The post office was first operated in 1898. The first school was constructed in 1939. After the school was built, families began to live at Koyukuk year-round. The city was incorporated in 1973. The community has experienced severe flooding from both the Yukon and Koyukuk Rivers, most recently in 2006. Significant erosion of the riverbank since the 1960s has also caused loss of structures, including homes, a Bureau of Indian Affairs (BIA) school, a church, a store, and two community halls. The community is considering relocation to a higher site within a few miles of the current location. Koyukuk has a small local road system, summer barge service, and a state-owned, lighted gravel airstrip. The airstrip was rebuilt in 2005–2006 to raise it above the floodplain.

Nulato

Located next to the Nulato Hills, Nulato lies on the west bank of the Yukon River across from the Kaiyuh Flats. Nulato is located 310 air miles west of Fairbanks and 35 miles west of Galena. The first trading post in the region was established at Nulato by the Russians in 1839. Nulato was a center of missionary activity. Many area Natives moved to the village after a Roman Catholic mission and school, Our Lady of Snows Mission, was completed in 1887. A post office was opened in 1897. Nulato incorporated as a city in 1963. During the 1970s, a clinic, water supply, new school, and telephone and television services were developed. In 1981, housing development began above the floodplain at a new townsite located on the hills

north about two miles from the old townsite. Nulato has a small local road system, summer barge service, and an airstrip.

Kaltag

Kaltag is located on the west bank of the Yukon River at the base of the Nulato Hills, directly across the river from the Northern Unit Innoko. Some residents of Kaltag have historic ties to the Kaiyuh Flats and continue to use the southwest corner of the Northern Unit Innoko. The village is 335 miles west of Fairbanks, 33 miles southwest of Nulato, and 75 miles west of Galena. The community has undergone numerous changes over its 150-year history. It was located on an old portage trail which led east through the mountains to Unalakleet. It served primarily as a cemetery for surrounding villages until about 1900, when disease and starvation dramatically impacted the Native population. Survivors from nearby areas moved to Kaltag to regroup. During the next 30 years, mining and steamship activity caused a mini-boom in the area. A series of schools and post offices opened, closed, and re-opened again during this period. Modern facilities, including an airport and clinic, were constructed in the 1960s. The city government was incorporated in 1969. A lighted airstrip, regular barge service, and the 90-mile Old Man Trail to Unalakleet provide relatively good access into and out of the community.

Ruby

Ruby is located on the south bank of the Yukon River in the Kilbuck-Kuskokwim Mountains, just downstream from the confluence of the Melozitna and Yukon Rivers. It is about 230 air miles west of Fairbanks and 50 air miles east of Galena. Ruby lies adjacent to the western edge of the Nowitna. The 35-mile state-maintained road south to Long Creek Mine comes within eight miles of the (Nowitna) Refuge.

Ruby developed as a supply point for gold prospectors following a gold strike at Ruby Creek in 1907. The village was named for the red stones, thought to be rubies, found in the same creek. At the time, there was a telegraph station across the river at Melozi. In 1911, a second gold strike 30 miles south at Long Creek attracted hundreds more prospectors to the area. At one time, over 1,000 miners lived in Ruby and around the nearby creeks. Placerville, Poorman, Sulatna Crossing, Kokrines, and Long Creek were some of the area's boom settlements.

A post office was established in 1912, and Ruby incorporated as a city in 1913. Initially, the city was governed by miner's meetings, then later by Pioneer Igloo Number 5. After the gold rush, the population declined rapidly. By 1939, there were only 139 residents. During World War II, the mining operations were shut down and most of the residents left. After the war, the remaining residents of nearby Kokrines relocated to Ruby, and the population began to increase. Gold mining continues in the area on a very small scale. In 1998, Barry Clay discovered the largest gold nugget ever found in Alaska. It weighed over 294 troy ounces and was found in the Long-Poorman area. Ruby incorporated as a second class city in 1973. A clinic, water source, and schools were constructed in the 1970s. During the 1980s, telephones and television services were provided. Construction of a new water source, water treatment plant, and washeteria was completed during the past decade. Ruby is accessible by a lighted gravel airstrip, and barges make several deliveries each summer. Riverboats, trucks, snowmobiles, and ATVs are used for local transportation.

Tanana

Tanana is located on the north bank of the Yukon River a few miles west of its confluence with the Tanana River. The village is located about 130 miles west of Fairbanks and about 25 miles east of the Nowitna. Tanana was a traditional trading settlement for Koyukon and Tanana

Athabascans before European contact. In 1880, Harper's Station, an Alaska Commercial Company Trading Post, was established 13 miles downriver from the present townsite. In 1881, Church of England missionaries from Canada built a mission eight miles downriver. Between 1887 and 1900, an elaborate school and hospital complex, the St. James Mission, was constructed. It became an important source of services and social change along both rivers. In 1899, Fort Gibbon was founded at Tanana to maintain the telegraph line between Fairbanks and Nome. A post office was also established, and several other trading posts developed around the turn of the century. Fort Gibbon was abandoned in 1923. The St. James Hospital was transferred to the BIA administration in the 1920s. During World War II, an air base was established near Tanana as a refueling stop for the lend-lease aircraft program. New hospital facilities were built in 1949; and during the 1950s, hospital administration was transferred to the U.S. Public Health Service. The City of Tanana was incorporated in 1961. The hospital complex was a major employer during this period but was closed in 1982. Also in 1982, Tanana incorporated as a first class city to assume control of the local school system. The hospital facilities were remodeled for use as a health clinic, counseling center, tribal office, and Regional Elders' Residence. Tanana is accessible only by air and river transportation. The city maintains 32 miles of local roads and a dock on the Yukon River.

3.4.2.3 Social Infrastructure

Social infrastructure includes local government, housing, education, health services, local transportation, water and sewage systems, solid waste disposal, police and fire protection, and communication systems.

Galena and Tanana are first class cities. The other villages are incorporated second class cities. All eight villages have mayor-council governments. Traditional tribal governments are active in all of the villages.

All of the communities are eligible for land entitlements under the Alaska Native Claims Settlement Act. The native residents of area communities are shareholders in Doyon, Limited (the regional native corporation), members of the non-profit Tanana Chiefs Conference, and shareholders in local village corporations organized under ANCSA. These corporations have land holdings and are often involved in local business concerns. Table 3-13 lists the communities and their respective village corporations.

Table 3-13. ANSCA village corporations in the vicinity of the Refuge.

Community	ANCSA Village Corporation
Galena	Gana-A' Yoo, Limited
Hughes	K'oyitl'ots'ina, Limited
Huslia	K'oyitl'ots'ina, Limited
Kaltag	Gana-A' Yoo, Limited
Koyukuk	Gana-A' Yoo, Limited
Nulato	Gana-A' Yoo, Limited
Ruby	Dineega Corporation
Tanana	Tozitna, Limited

The communities have a similar infrastructure. Law enforcement is provided by city police departments in the villages of Galena and Tanana; village public safety officers in Huslia, Nulato, and Ruby; and the Alaska State Troopers in all villages.

Elementary and secondary schools are available in all of the villages. The Tanana Chiefs Conference offers the Headstart program for preschoolers in Nulato, Ruby, Tanana, Kaltag, and Huslia. Galena's Headstart program is run by Galena City Schools. The Galena School District also operates the Galena Interior Learning Academy, a high-school level boarding school, as well as the IDEA home-school support program.

Health facilities are provided in the villages by the Indian Health Services, which is under the U.S. Department of Health and Human Services. Clinics are staffed by health aides trained by the U.S. Public Health Service (PHS). Galena has medical and mental health facilities at the city-owned Edgar Nollner Health Center, which also provides services to outlying villages. In addition, PHS physicians and other health caregivers visit the villages regularly.

Communications facilities are relatively good in the area. Post offices, satellite communications (telephone and television), and electricity are available in all of the communities. The region is served by a public radio station (KIYU) located in Galena.

Housing consists of both wood frame and log homes. Most homes date from the 1960s, although more recent construction is common. Public lodging is available in Galena, Ruby, Huslia, and Tanana. Community water and sewage systems are available and serve most residents. Many residents haul water from a public water source (drilled wells). Some of the Galena residents are served by a centralized water system.

3.4.3 Subsistence Way of Life

In 1980, the U.S. Congress passed the Alaska National Interest Lands Conservation Act (ANILCA), which established the Refuge, among other conservation system units. One of the purposes of the Act, and of the Refuge, is to provide the continued opportunity for rural residents engaged in a subsistence way of life (ANILCA sec. 101(c)). Subsistence is regarded as a way of life rather than merely a recreation activity. The meanings of subsistence are based on family traditions, religion, relationships with particular places, and a preference for natural foods.

Several communities rely on the resources of the Refuge for subsistence purposes: Hughes, Huslia, Koyukuk, Nulato, Kaltag, Galena, Ruby, and Tanana are all either within or adjacent to the Refuge. The primary subsistence-use areas within the Refuge are the rivers and river corridors of the Yukon, Koyukuk, Huslia, and Nowitna rivers, as well as the Kaiyuh Flats and Dulbi Slough.

A wide variety of subsistence activities occur year-round on the Refuge, while other activities are seasonal and depend upon the resource and the location of the activity. Waterfowl hunting is a common subsistence use in late spring and fall. Fishing for northern pike, by jigging through the ice, is typical in early spring. As spring turns to summer, salmon fishing begins, starting with Chinook and summer chum and then progressing to coho salmon and fall chum in late summer and fall. Sheefish and other whitefish species are also caught during the summer. Moose hunting, berry picking, firewood gathering, and the gathering of other plants are primarily fall activities. Throughout the fall, black fish, burbot, and whitefish are harvested. As lakes and rivers begin to freeze in early winter, nets are often set under the ice for whitefish and northern pike. Other animals hunted during the fall and winter months are spruce and ruffed grouse, ptarmigan, snowshoe hare, muskrat, beaver, and black and grizzly

bear. Trapping begins after the lakes and ponds have frozen, usually early November. Marten, beaver, lynx, and fox are the primary furbearers trapped. Other species include: muskrat, mink, otter, wolf, and wolverine. Early spring is also a traditional time to harvest moose and caribou, provided populations are stable.

Following is a description of subsistence activities in the villages surrounding the Refuge.

Hughes

There are strong social ties between the residents of Hughes and Allakaket. The stretch of river that lies between to two villages is the focus of many subsistence activities. Moose are a primary source of protein in Hughes, although they were generally not hunted before the 1930s. Residents of Hughes hunt moose along the Koyukuk River, from the mouth of the Kanuti River to below Hog Landing and up the Little Indian River. Most of the effort is concentrated in the Huggins Island–Matthews Slough area on the Koyukuk. The river corridor that is used for moose hunting is also used for black bear, waterfowl, and some small game hunting. Black bear are hunted primarily in the early fall, though a few are taken in the spring.

Hughes residents also participate in bird and waterfowl hunting. In 1998, residents harvested a total of 130 ducks and 128 geese, nearly 7.3 birds per capita, the highest in the region (Webb 1999). Most of the small game hunting takes place in the area surrounding the community. Common species taken include snowshoe hare, grouse, and ptarmigan.

Caribou have historically been a more important food source. More recently, when the Western Arctic caribou herd comes into the Hughes-Huslia area, residents will hunt them.

Fish comprise the largest volume of food harvested in Hughes. Summer run chum salmon make up a major portion of this harvest. Much of the fishing is done using set nets at fish camps along the Koyukuk River from Discovery Creek to Florence Island. The lower part of this harvest area is within the (Koyukuk) Refuge boundary. Most of the fishing occurs downstream from the community where the salmon are more abundant and in better condition. Non-salmon fish, including blackfish, burbot, grayling, northern pike, sheefish, sucker, and whitefish are also harvested. Whitefish species—such as broad, humpback, and cisco—are harvested mainly with a set or seine net along the Koyukuk River. In 2002, an estimated 12,541 pounds of non-salmon fish (burbot, grayling, pike, sheefish, sucker, and whitefish) were harvested by Hughes residents (Andersen et al. 2004).

Trapping areas, used by the residents of Hughes, include the general area from the Hatdolitna hills west to the Hogatza River and from the Klikhtentotzna Creek area south to the Takhakhdona Hills. The southern portion of Hughes trapping area is within the (Koyukuk) Refuge boundaries.

Plant gathering is an activity which fulfills a wide range of needs in the community. Most buildings, including houses, smokehouses, and storage buildings, are built from local timber. Wood heat is the norm, while smaller poles are used for wall tents and fish drying racks. Firewood is generally gathered close to town, along the Koyukuk River between Hughes and Allakaket or in a nearby burn area.

Huslia

Huslia is the only community in the region that is located within the boundaries of a Refuge. Due to Huslia's location, the subsistence activities of Huslia residents (2004 census indicated 269 individuals) are focused on the Koyukuk, and they often utilize resources in a large proportion of the Refuge.

Large mammal hunting in Huslia is concentrated on moose, caribou, and black bear. Huslia residents mainly hunt for large mammals along the Koyukuk, Huslia, and Dulbi River corridors. Caribou are taken when available. On average, 77 moose, 120 caribou, and 26 black bear were harvested annually from 1996 to 2003 by Huslia residents (Brown et al 2004).

Waterfowl and small game are also important food sources to Huslia residents. In 1998, 535 ducks and geese were harvested in the area surrounding Huslia (Webb 1999). Small game hunting has concentrated on hares, beaver, muskrat, ptarmigan, and grouse.

Trapping is a major subsistence activity in Huslia. During the first part of the trapping season, marten, fox, and lynx are the focus of the harvest. In February and March, the emphasis shifts to beaver. They are harvested for their meat and their pelts. The area used for trapping by Huslia residents extends over much of the Koyukuk. To the north, people use the area up the Dakli River, nearly to the Continental Divide. Cutoff Slough and the mouth of the Hogatza River are also important areas. The Holitnakakatina Creek and Natlaratlen River areas, to the south of Huslia, are also trapped. Trapping areas include (Koyukuk) refuge lands from the Nayuka and upper Dulbi Rivers to Three Day Slough and along the Huslia River to the Nulato Hills to the west.

The people of Huslia primarily harvest fish along the Koyukuk River, from Cutoff Slough to the mouth of the Dulbi River. Nets are set for sheefish and whitefish in May, as soon as the ice melts. In 2002, the total community harvest of these species was 873 sheefish and 4,650 whitefish. A total of 33,635 pounds of non-salmon fish (blackfish, burbot, lake trout, grayling, pike, sheefish, sucker, and whitefish) were caught in 2002 (Andersen et al. 2004). Summer chum salmon are the most heavily harvested of the fish species. Fall chum salmon, pike, and Chinook salmon are also important harvest species.

Galena

Galena's central location allows residents to use the Refuge. Large mammal hunting in Galena focuses mainly on moose, although bear and caribou are taken, when available. The Yukon and Koyukuk rivers and their tributaries are used for traveling to moose and black bear hunting areas. The Alaska Department of Fish and Game Brown et al. (2004) reported 110 moose were harvested (on average) each year from 1997–2003 by Galena residents. During the same time period, an average of 17 caribou and 11 black bear were harvested each year (Brown et al. 2004).

Galena residents harvest fish primarily from the Yukon River. A smaller percentage of fish are caught in tributaries, sloughs, and lakes off the Yukon River. Set nets, drift nets, and fish wheels are utilized for harvesting salmon. From 1994–1998, an average of 1,992 Chinook, 2,792 summer chum, 3,814 fall chum, and 636 coho salmon were harvested each year. From 1999–2003, an average of 1,943 Chinook, 712 summer chum, 955 fall chum, and 402 coho salmon were harvested each year (Busher et al. 2008). From 1999–2003, an average of 1,943 Chinook, 712 summer chum, 955 fall chum, and 402 coho salmon were harvested each year (Busher et al. 2008).

Harvest of furbearers by Galena residents is still a very active subsistence activity. Residents of Galena use the both Refuge and the souther unit of Innoko Refuge for furbearer trapping.

Nulato

Nulato residents use the Kaiyuh Flats, refuge lands along the Yukon River and up the Koyukuk River, as far as the Three Day Slough area, and the Nikolai Slough northwest of Galena.

People from Nulato generally use areas of the Kaiyuh Flats for trapping, which is productive for beaver and mink. Trapping for furbearer species occurs in late winter, usually February through April. Similar to the other communities in the region, the residents of Nulato depend on moose, bear, waterfowl, small game, and fish for protein. Caribou are also hunted in the Nulato Hills when available.

Brown et al. (2004) estimated Nulato residents, on average, annually harvested 58 moose from 1996 to 2003. During the same time period, an average of four caribou and three black bear were harvested (Brown et al. 2004). In addition to sheefish, whitefish and pike, salmon is the main protein source for fish species that is harvested by residents. In particular, Chinook salmon make up a large percentage of the overall salmon harvested. From 1994–1998, an average of 2,090 Chinook, 1,168 summer chum, 1,122 fall chum, and 136 coho salmon were harvested each year (Busher et al. 2008). From 1999–2003, an average of 1,863 Chinook, 596 summer chum, 766 fall chum, and 299 coho salmon were harvested each year (Busher et al. 2008)

Waterfowl hunting occurs in late spring and fall in the lakes and sloughs of the Northern Unit Innoko. During the 1997 hunting season, Nulato residents harvested 211 ducks and 160 geese (Webb 1999).

Koyukuk

As with other communities in the region, the residents of Koyukuk depend on the resources of the Refuge for their living. Koyukuk residents use portions of both Koyukuk and Northern Unit Innoko. Use of the Koyukuk is centered on the Koyukuk River, from the Three Day Slough area south to the Yukon River, including parts of the Natlaratlen River to the east and the Gisasa, Honhosa, and Kateel rivers in the west. Use of the Northern Unit Innoko takes place in the northwest portion, primarily the Squirrel Creek drainage and north to the Yukon River.

Similar to other communities in the area, Koyukuk residents depend mainly on moose and salmon for the majority of their protein; and bear, caribou, small game, waterfowl, other fish, and plants are also harvested when available. Residents of Koyukuk harvested an annual average of 14 moose from 2001–2007 (ADF&G 2008). During the 1997 spring and fall waterfowl hunting season, residents of Koyukuk harvested 202 ducks and 209 geese (Webb 1999).

Kaltag

Some of the residents of Kaltag have historic ties to the Northern Unit Innoko and continue to use the southwest corner of the Refuge and the area south of Kaltag from Kaiyuh Slough along the Yukon and Khotol rivers. Most of the resource use by Kaltag residents occurs off of the Northern Unit Innoko.

As in the other communities in the region, Kaltag residents depend on moose, waterfowl, small game, and fish for protein. Caribou are also taken in the Nulato Hills when available. Berries are harvested for food, and wood is gathered for fuel and building materials.

On average, 41 moose were harvested annually by Kaltag residents from 1996–2003. Most moose hunting done by residents takes place along the Yukon River and its smaller tributaries. A considerable portion of protein harvested by Kaltag residents comes from salmon. During the 1994–1998 salmon fishing seasons, an annual average of 1,489 Chinook, 820 summer chum, 793 fall chum, and 220 coho salmon were harvested. During the 1999–2003 fishing seasons, an annual average of 1,581 Chinook, 413 summer chum, 520 fall chum and 330 coho were caught (Busher et al. 2008).

Ruby

Ruby residents mainly subsist along the Yukon River corridor and its smaller tributaries. The Nowitna is used by residents of Ruby for their subsistence activities. From 2001–2007, residents have annually harvested 16 moose on average. Caribou and black and grizzly bear are harvested when available.

Along with whitefish, sheefish, and pike, residents harvest salmon by using fish nets and/or fish wheels. Salmon species make up the majority of harvested fish species. During the 1994–1998 salmon fishing seasons, an annual average of 1,936 Chinook, 3,317 summer chum, 3,086 fall chum, and 975 coho salmon were harvested. During the 1999–2003 fishing seasons, an annual average of 1,194 Chinook, 1,247 summer chum, 792 fall chum, and 476 coho were caught (Busher et al. 2008).

Tanana

Tanana residents mainly subsist along the Yukon and Tanana River corridors and their tributaries. Tanana residents—to a lesser extent than Ruby residents—also use the Nowitna for subsistence activities. Moose, waterfowl, and small game are harvested on the Nowitna by residents.

Similar to other communities in the area, Tanana residents mainly depend on moose and salmon but also harvest caribou, bear, non-salmon fish species, small game, berries, and other plant material when available. From 2001–2007, residents of Tanana harvested eight moose annually (ADF&G 2008). During the 1994–1998 salmon fishing season, an annual average of 3,389 Chinook, 4,073 summer chum, 24,105 fall chum and 3,294 coho salmon were harvested (Busher et al. 2008). During the 1999–2003 fishing season, an annual average of 3,621 Chinook, 2,373 summer chum, 12,406 fall chum and 4,200 coho were caught (Busher et al. 2008).

3.4.4 Recreation

3.4.4.1 Overview

Recreational visitors access the Refuge by boat, snowmobile, or small airplane. The Refuge issues special use permits for commercial air and boat taxis each year, and some visitors arrive in private boats or airplanes. There are no recreational facilities located on the Refuge.

Although wildlife observation and photography, camping, berry picking, and other incidental activities do occur on the Refuge, the primary purpose of most recreational visits is moose hunting or fishing. Moose hunting is the one activity most often associated with the Refuge.

3.4.4.2 Moose Hunting

The Refuge lies within portions of Alaska Game Management Units (GMU) 21B, 21C, 21D, 24C, and 24D (Figure 1-3). A portion of the Koyukuk is within the Koyukuk Controlled Use Area identified by the Alaska Board of Game. The Controlled Use Area is closed during moose hunting season to the use of aircraft for hunting moose. Since fly-in hunting is primarily recreational, the Controlled Use Area generally restricts recreational hunters. The bulk of recreational hunting on the Refuge occurs in GMU 21B and 21D along the Nowitna and Koyukuk rivers.

In 1993, permitting regulations were restructured on all Alaska National Wildlife Refuges and nine, sole-use big-game guide areas were established on the Refuge. Five sole-use big-game guide areas were started on the Koyukuk, three on the Nowitna, and one on the Northern Unit Innoko (Figure 3-11). At present, there are three big-game guides permitted to operate

on the Koyukuk (one guide holds the permit for all three areas), two on the Nowitna (one guide holds the permit for two areas), and none for the Northern Unit Innoko. Each big-game guide, under his/her prospectus application, is required to report the number of clients, moose taken, and areas to be hunted.

3.4.4.3 Fishing

Each year, the Refuge issues one or two special use permits for fishing guides who primarily advertise opportunities to catch trophy-sized northern pike. At present, one fishing guide operates on the Nowitna and one on the Northern Unit Innoko.

3.4.4.4 Environmental Education and Interpretation Programs

The Refuge has an Environmental Education program aimed at promoting a greater public understanding and appreciation of the ecology of fish and wildlife, habitat preservation, and refuge management. Activities include school and community programs held in the eight villages adjacent to the Refuge; development and distribution of educational resources, curricula, and teaching kits; and public contact via an informational kiosk, displays, radio programs, newsletters, brochures, and Web sites. The Refuge partners with Galena schools and Louden Tribal Council to conduct a two-week Galena Science Camp for elementary students each summer. Refuge staff members also participate in student camp programs in other villages as opportunities arise.

3.4.5 Economy

The region surrounding the Refuge is sparsely populated and relatively undeveloped. Opportunities for year-round salaried employment are fairly limited, and overall income level is low. Subsistence hunting and fishing remain vitally important to the rural lifestyle and economy. Harvest of big game and fish predominates, supplemented by waterfowl harvest and the use of plant resources. Harvest of these traditional foods is basic to a rural economy. Grocery prices are among the highest in the State because transportation charges to these small remote communities are high.

Traditional cash-generating activities of the region (gold mining, commercial fishing, firefighting, and trapping) all suffered significant declines during the 1990s (Windisch-Cole 2001). In 2006, the economy of the Yukon-Koyukuk Census Area supported nearly 2,200 year-round jobs, and over 65 percent were local, state, or federal government positions (Alaska Department of Commerce, Community, and Economic Development 2008). Local governments and school districts are the dominant employer. Within the private sector, many jobs are associated with Alaska native organizations, many of which provide services under contract with non-profit or government entities. Construction activity, another important private sector employer, also largely depends on public funding. Public subsidies are common and needed in most communities.

Overall wage and salary income within the Yukon-Koyukuk Census Area is well below the State average. In 2004, the median family income was just over $39,000, more than 45 percent below the statewide median. In early 2008, the unemployment rate was just over 17 percent, compared to less than 8 percent statewide (Alaska Department of Commerce, Community, and Economic Development 2008). The expense of travel and daily life in the area compounds the effect of low employment and low family incomes.

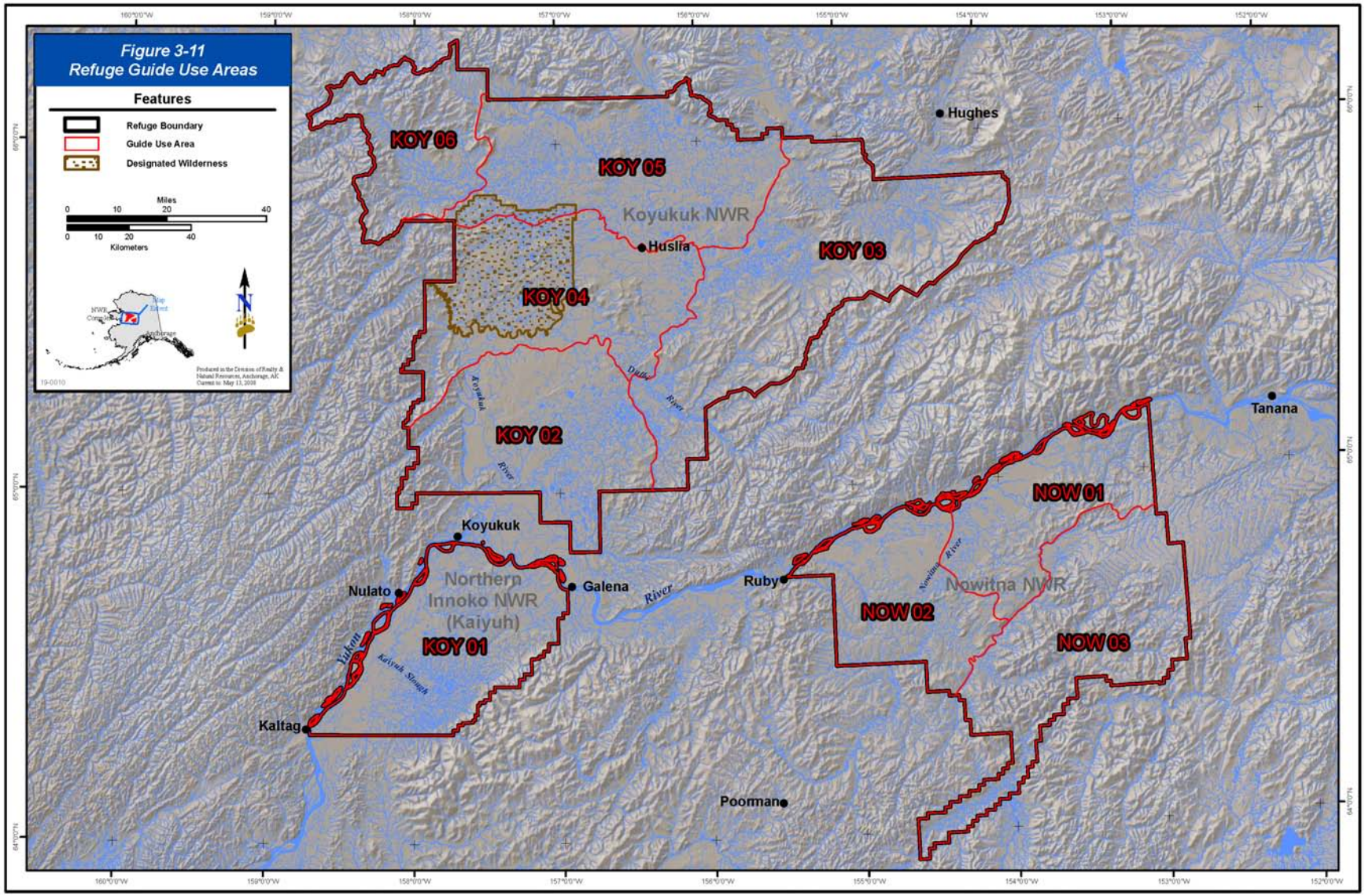


Figure 3-11. Refuge Guide Use Areas

Employment and income statistics do not provide a complete picture of regional economic conditions because of the important role of subsistence hunting and fishing. Personal income statistics can give a misleading picture of the well-being of residents of communities in which subsistence is a significant source of food and other needs. Such communities often have more resources available than is reflected by personal income. Nevertheless, even in the most subsistence-oriented communities, cash is still needed for the purchase of fuel, food, firearms, ammunition, fishing gear, snowmobiles, boats, and associated materials and maintenance costs.

3.4.6 Regional Access

Historically, boats and dog sleds were the only means of access to the Refuge. The advent of outboard motors and snowmobiles has brought many changes to local transportation and the harvest of wild resources. Now almost all visitors to the Refuge use motorboats, snowmobiles, or aircraft for access. There are no established landing strips currently on the Refuge, so aircraft must be equipped for landings on snow, water, or gravel bars. There is no known local use of three- or four-wheelers or other off-road vehicles for access to subsistence resources on the Refuge. This finding is based on interviews of elders in the villages of Huslia, Ruby, and Galena.

Residents use trucks and other automobiles, off-road vehicles (primarily four-wheelers), and snowmobiles for transportation within the villages. Boats, airplanes, and snowmobiles are used for travel between villages and in surrounding areas. No roads connect these villages with any other community. All of the villages have airstrips and are served by regularly scheduled commercial flights and local air charter operators. The availability of regularly scheduled flights to Fairbanks or Anchorage varies from village to village. Most villages have a minimum of five daily flights per week. Seasonal barge service is available in all villages, depending on water level. More service is available to villages located on the Yukon River. Access to the Refuge is relatively good by interior Alaska standards, and no proposals for additional means of access have been identified.

3.5 Wilderness Values

3.5.1 Introduction

Section 304(g) of ANILCA requires the Service to identify and describe the special values of the Refuge, including wilderness values. The term "values" is often viewed synonymously with a range of similar terms, from subjective beliefs and preferences (e.g., family values) to more objective functions, services, and benefits (e.g., ecological values). Of interest here are the objective kinds of values, specifically those that are related to the condition and wild character of the natural environment.

The 1964 Wilderness Act (Act) recognized wilderness as a resource in and of itself and also established a mechanism for preserving that resource in a national system of lands. The definition of wilderness found in the Act provides a framework for identifying and describing wilderness values. According to the Act, the fundamental qualities of wilderness are undeveloped, untrammeled, natural, and outstanding opportunities for solitude, or a primitive and unconfined type of recreation. These qualities are defined below. In addition, the Act states that wilderness "may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." The 1987 Plan evaluated eight potential areas (see section 3.5.3 through 3.5.10) for inclusion as wilderness. Only the Koyukuk Wilderness was designated as a Wilderness Area.

3.5.1.1 Undeveloped

This is the most immediately observable and easily measured wilderness quality. Undeveloped simply means free from roads, structures, and other evidence of modern human presence or occupation. The undeveloped quality strongly influences other core wilderness values—in particular, experiential opportunities for solitude and primitive recreation. A lone structure may have only minimal impacts on natural processes while still serving as a constant reminder of human influence for recreational visitors. Certain kinds of structures or improvements may be considered desirable in a given wilderness setting (e.g., trails) or acceptable according to specific legislation, but that does not diminish their negative impact on the undeveloped quality.

3.5.1.2 Untrammeled

The Wilderness Act states that wilderness is "an area where the earth and its community of life are untrammeled by man." In other words, wilderness is essentially uncontrolled or unrestricted by purposeful human actions. Synonyms for untrammeled include uncontrolled, unmanipulated, self-willed, and wild (Landres et al. 2005). The untrammeled quality of the wilderness resource is diminished when ecological events or processes are constrained or redirected to suit modern human ends (e.g., by suppressing naturally ignited fires or introducing non-native plants or animals).

3.5.1.3 Natural

Naturalness is a measure of the overall composition, structure, and function of native species and ecological processes in an area. In contrast to the quality of being untrammeled, the natural condition of an area may sometimes be enhanced through purposeful human action (e.g., to restore an eroded stream bank or eradicate an invasive weed).

3.5.1.4 Outstanding Opportunities for Solitude

Solitude in the wilderness context is generally understood to mean freedom from sights, sounds, and other evidence of modern man (Landres et al. 2005). While the relative amount of freedom from these things necessary to experience solitude is highly personal and variable, the Act states only that outstanding opportunities for solitude be provided. Accordingly, encountering other people, hearing mechanized sounds (from aircraft overflights, for example), or seeing the lights of a distant population center are all examples of things that may negatively impact solitude opportunities; while remoteness, low visitor density, and vegetative or topographic screening are things that may enhance solitude opportunities.

3.5.1.5 Outstanding Opportunities for a Primitive and Unconfined Type of Recreation

Primitive and unconfined recreation occurs in an undeveloped setting and is relatively free from social or managerial controls. Primitive recreation in wilderness has largely been interpreted as travel by non-motorized and non-mechanical means. Primitive recreation is also characterized by experiential dimensions such as challenge, risk, and self-reliance. Dispersed use patterns, which frequently occur where there are no facilities, enhance opportunities for self-reliance and solitude. Conversely, some actions aimed at maintaining opportunities for solitude, such as limited permit management systems, may negatively impact opportunities for unconfined experiences.

3.5.1.6 Other Special Features

Lands that exhibit the core wilderness qualities described above may also contain additional special features of scientific, educational, scenic, or historic value. While the Act makes it clear that although these features are not wilderness qualities in and of themselves, their presence may distinguish one area with wilderness values from another. In the context of Alaska refuges, special features might include such things as active volcanoes, unique abundance or concentrations of a given species, fossil deposits, or evidence of prehistoric cultures.

In 1980, 400,000 acres of the Koyukuk was designated as a Wilderness Area by ANILCA. Additionally, as directed by sections 304(g) and 1317 of ANILCA, lands currently administered by the Refuge were reviewed during preparation of the first Plan in 1987 "as to their suitability or non-suitability for preservation as wilderness" (see section 2.7.2 and sections 3.5.3 through 3.5.10 for more detail). The following identification and description of wilderness values is based on that review, with additions and amendments as appropriate.

3.5.2 Characteristics Common to All Units

In designating the Koyukuk Wilderness Area (Figure 3-12), Congress found that it exhibits the characteristics of wilderness described in the Wilderness Act. Refuge lands within the following wilderness review units also exhibit all the core wilderness values: Purcell Mountain, Takkakhdona Hills, Coffee Can Lake, Kaiyuh Flats, Nowitna River, Little Mud, and Big Creek. They are largely undeveloped, untrammeled, highly natural, and support abundant opportunities for solitude and primitive recreation. All of these management units support the full suite of fish and wildlife species and plant communities representative of local ecosystems.

Topographic variation provides a variety of wildlife habitats within each unit. Habitat diversity is created through several natural processes: river meander, ice scouring and spring flooding, and wildland fire. The meandering rivers of the Refuge constantly change course by forming and then cutting through oxbows creating isolated oxbow lakes. The floodplains are dotted with lakes in various stages of successional development, creating ideal habitats for nesting, staging, and migrating waterfowl. Meandering rivers also produce diverse terrestrial habitat as erosion destroys mature vegetation on the outside of river bends and deposits gravel bars on the inside of bends. Gravel bars are colonized by early successional plants such as willows, which are extremely valuable moose browse. During spring breakup events, large blocks of ice scour vegetation growing along riverbanks, stimulating the growth of earlier successional plants such as herbs and young willows. Ice jams formed during breakup cause flooding, which replenishes nutrients in floodplain lakes and sloughs. Wildland fires convert mature plant communities to early seral stages and recycle nutrients that help sustain ecosystems. Hot dry summers and afternoon thunderstorms provide lightning for ignition that has given this region as rich a fire history as any in the State.

Although the units generally have very few visible signs of human manipulation or permanent human presence, there are scattered trapping cabins and remnants of other uses within some of them. Major rivers are important travel corridors for wildlife and for local residents traveling between villages and/or participating in subsistence activities. Many of the rivers are suitable for float trips. Winter travel by snowmobile mainly occurs on rivers and traditional trails. Travel away from these areas can be quite challenging but offers excellent opportunities for solitude and primitive recreational experiences.

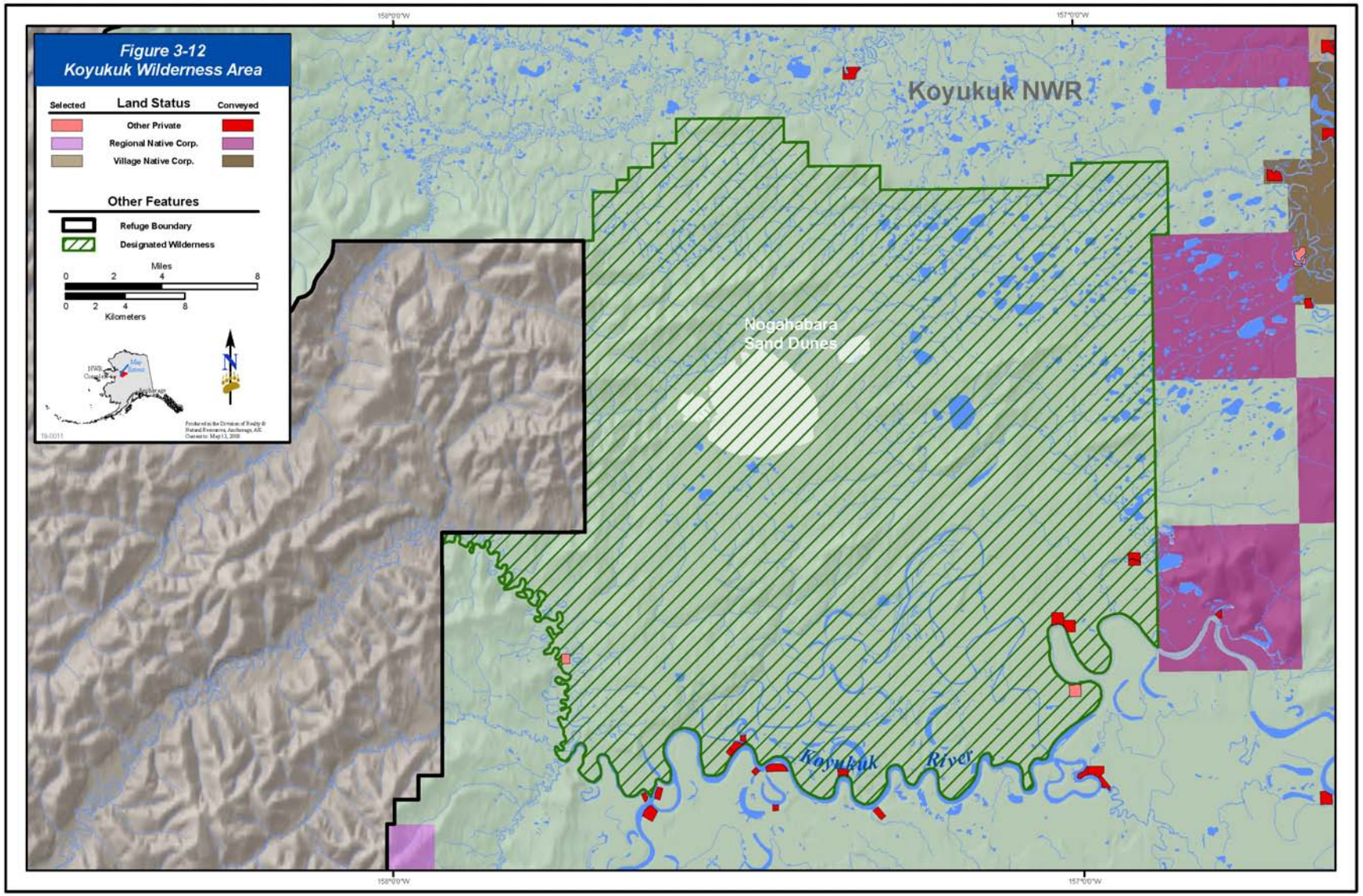


Figure 3-12. Koyukuk Wilderness Area

3.5.3 Koyukuk Wilderness Area

The 400,000-acre designated Koyukuk Wilderness Area lies north of the Koyukuk and Kateel rivers, and encompasses the Nogahabara Sand Dunes. Formed thousands of years ago when sand from melting glaciers blew up against the Nulato Hills, these spectacular sand dunes are constantly shifting in the wind. The dunes range from 50 to 100 feet high and may be over 300 feet in length. Portions of the dune plant community are relics from the last ice age.

Also within the Koyukuk Wilderness is Three Day Slough, a wildlife-rich and productive area of forest and wetlands just off the main stem of the Koyukuk River. Travel in the interior of the Koyukuk Wilderness is difficult, but Three Day Slough is navigable by boat during high-water conditions, and the area is popular for fall moose hunting. Away from the Three Day Slough area, most of the topography within the Koyukuk Wilderness Area consists of rolling stabilized dunes dotted with lakes and covered by white spruce and aspen communities.

The following areas were analyzed during preparation of the 1987 Plan and were found suitable for wilderness designation but were not recommended for inclusion as wilderness (see section 2.7.2 for more details).

3.5.4 Purcell Mountain Unit (Koyukuk)

The continental divide dominates this 840,000-acre unit, forming the northernmost boundary of the unit and the Koyukuk. The divide follows the ridgeline of the Purcell Mountains and forms the headwaters of Huslia River. Elevation in the unit ranges from Purcell Mountain at 3,831 feet to less than 200 feet where the Huslia River enters the Koyukuk River. Extensive wetlands in the unit are characterized by numerous thaw lakes and tightly meandering streams. Part of the Western Arctic caribou herd frequently winter within the Purcell Mountain region. The unit is bounded on the south by the Koyukuk Wilderness and on the east by a block of privately owned or selected lands. Although difficult to access, the Purcell Mountains and foothills provide good hiking and backpacking opportunities, with scenic vistas in all directions visible from the continental divide.

3.5.5 Takhakhdona Hills Unit (Koyukuk)

This unit covers approximately 1,009,000 acres within the eastern portion of the Koyukuk. Topography ranges from 3,000 foot mountains to lowlands below 200 feet in elevation. The most noticeable topographic features are 3,126-foot high Hochandochtla Mountain on the refuge boundary south of the Takhakhdona Hills, the Koyukuk River, and several large lakes within the Koyukuk River floodplain. The unit contains a vast region of productive wetlands that support large populations of waterfowl as well as other boreal forest wildlife. The Koyukuk River is an important migration stream for salmon and an important transportation route for local people and visitors. The Takhakhdona Hills unit includes numerous important archaeological sites in the Hahanudan Lake and Indian River areas, adding to its unique character.

3.5.6 Coffee Can Lake Unit (Koyukuk)

Extensive wetlands of the Koyukuk River floodplain (Koyukuk Flats) dominate this 1,500,000-acre unit. The Koyukuk River drains south along the western portion of the unit. The eastern portion is drained by the Dulbi River, a tributary of the Koyukuk River. Mountains in the eastern and western portions of the unit contribute to topographic and ecosystem diversity. The floodplain is 5–20 miles wide, with meander belts along the rivers and thaw (thermokarst) lakes away from the rivers. Broad, rolling silt plains, mantled in part by dunes and in places where there are abundant thaw lakes, stand 100–200 feet above the central plains and merge

into the surrounding uplands. Several low bedrock hills rise from the center of the lowlands. The Galena Mountain caribou herd, a small resident herd, winters near Coffee Can Lake and spends summers on the eastern side of the unit in the Kokrine Hills.

3.5.7 Northern Unit Innoko

The southeastern portion of the unit extends up the northwest slope of the Kaiyuh Hills to an elevation of nearly 3,000 feet. However, the majority of the unit is comprised of low lying wetlands with abundant lakes, and meandering streams that drain into the Yukon River. The primary vegetation along the water courses consists of alder, willow, and grasses, with white spruce growing on the better drained sites. The wetland ecosystem found here is subject to frequent spring flooding and produces abundant populations of fish, waterfowl, and furbearers. The area has long been of great importance for human subsistence. A large portion of the unit has been selected for private (village and native corporation) ownership. Federal ownership is approximately 379,000 acres (50 percent). Primary access is by boat; however, navigation can be difficult in the vast maze of wetlands.

3.5.8 Nowitna River Unit (Nowitna)

The dominant feature of this 325,000-acre unit is the 223-mile segment of the Nowitna River that was designated by ANILCA as a Wild River in the National Wild and Scenic River System. The wilderness review unit encompasses the Wild River corridor as well as 182,600 additional acres within the Nowitna River floodplain and several islands in the Yukon River. Most of the unit is a broad flat floodplain with the exception of the 16 miles of Nowitna Canyon where the river cuts through the foothills of the Kuskokwim Mountains.

Wetlands in the Nowitna River floodplain are less acidic and more productive than many others in Alaska. This is because spring flooding caused by ice damming during breakup enriches the lakes and sloughs with nutrients and carbonates from the limestone bedrock in the Nowitna headwaters. The carbonates buffer the pH of the naturally acidic wetland waters.

White spruce size and density in this unit are uncommon in interior Alaska. The mixture of mature forest and early successional plant communities make the Nowitna River corridor the best winter and spring moose habitat on the Nowitna. Mature spruce forests provide nesting areas for raptors and are excellent marten habitat.

Most public use of the unit occurs on the Nowitna River during fall moose hunting season, and includes boat and floatplane use. There are several native allotments, trapping cabins, and one administrative cabin located along the Nowitna River. However, most of these are not visible and generally do not detract from the sense of naturalness. Outside of moose hunting season and summer boat traffic on the Yukon, visitors are unlikely to encounter others within the unit.

3.5.9 Little Mud Unit (Nowitna)

Bounded to the west by the Nowitna River corridor and extending east to the refuge boundary, this unit encompasses nearly 1,132,800 acres. The Little Mud River is one of three major tributaries of the Nowitna River that flow across the unit from northeast to southwest. Several islands in the Yukon River are also included in the unit. The Palisades lies along the Yukon River. It is an impressive series of silt bluffs extending seven miles along the south bank. The bluffs are locally called the "Boneyards" because Pleistocene fossils often wash out of the frozen silt as the bluffs erode. The Palisades are an important site for paleo-environmental research.

The northern third of the Little Mud Unit is part of the Nowitna Lowlands, a broad plain studded with marshes, bogs, and thaw ponds. The remainder of the unit consists of vegetated sand dunes and bedrock hills rising to over 2,000 feet in elevation. The Boney Creek Dissected Benchlands on the eastern edge of this uplifted region are an unusual geological feature that was recommended as a Geological Landmark in Alaska (Young and Walters 1982). These flat-topped mesas dissected by small parallel drainages resemble canyon land topography associated with the southwestern United States.

Access to this unit of the Nowitna is extremely difficult, and human use is primarily limited to areas along the Yukon River. There is one administrative cabin in the unit.

3.5.10 Big Creek Unit (Nowitna)

This unit covers the Nowitna west of the Nowitna River unit. The majority of the 418,000-acre unit is composed of the flat wetlands of the Nowitna Lowland but also includes several islands in the Yukon River. A high ridge rising to 2,300 feet, which is an extension of the Kuskokwim foothills, makes up the southern end of the unit. Vegetation in the lowlands is primarily conifer (sparse black spruce) and an understory of Labrador tea, bog blueberry, cranberry, and sphagnum moss. The high country is forested with white spruce and birch, giving way to subalpine broadleaf scrub at timberline. Moose hunting, fishing, berry picking, wildlife viewing, and camping occur in the unit; but the unit is seldom visited, and recreation is concentrated on the Sulatna and Yukon Rivers where access is good and wildlife resources are most abundant.

3.6 River Values

3.6.1 Introduction

Section 304(g) of ANILCA requires the Service to identify and describe certain values of the Refuge including *"…archeological, cultural, ecological, geological, historical, paleontological, scenic, or wilderness values…"* River resources may contain a variety of these and other values and thus should be described and evaluated.

Section 5(d) of the 1968 Wild and Scenic Rivers Act (U.S. Congress 1968) requires that federal agencies consider river values in developing land use plans:

> *"In all planning for the use and development of water and related land resources, consideration shall be given by all Federal agencies involved to potential national wild, scenic and recreational river areas, and all river basin and project plan reports submitted to the Congress shall consider and discuss any such potentials. The Secretary of the Interior and the Secretary of Agriculture shall make specific studies and investigations to determine which additional wild, scenic and recreational river areas within the United States shall be evaluated in planning reports by all Federal agencies as potential alternative uses of the water and related land resources involved."*

The act recognizes the importance of a river's free-flowing nature and specific "outstandingly remarkable values" such as scenery, recreation, geology, fish and wildlife, history, and any other feature that makes a river unique. Thus, an analysis of river resources consists of an examination of the river's hydrology, including man-made alterations, and an inventory of its natural, cultural, and recreational resources. In order to be assessed as outstandingly remarkable, a river-related value must be a unique, rare or an exemplary feature that is

significant at a comparative regional or national scale. While the spectrum of resources that may be considered is broad, all values should be directly river-related and should:

1. be located in the river or on its immediate shore lands (in Alaska, generally within one-half mile on either side of the river);
2. contribute substantially to the functioning of the river ecosystem; and/or
3. owe their existence or location to the presence of the river.

Rivers and streams that are both free-flowing and possess at least one outstandingly remarkable value meet the eligibility criteria put forth by the Wild and Scenic Rivers Act. These rivers should then be classified as wild, scenic, or recreational based upon the type and degree of human development(s) associated with the public lands involved at the time of the review. The actual classification is determined by Congress. The Nowitna River has been designated and is managed as a wild river (Figure 3-13).

The river classifications are described as:

Wild

These are waterways or sections of waterways on public lands that are free of impoundments and generally inaccessible except by trail and with watersheds or shorelines essentially primitive and waters unpolluted.

Scenic

These are waterways or sections of waterways on public lands that are generally free of impoundments with watersheds still largely primitive and shorelines still largely primitive and largely undeveloped but still accessible by roads.

Recreational

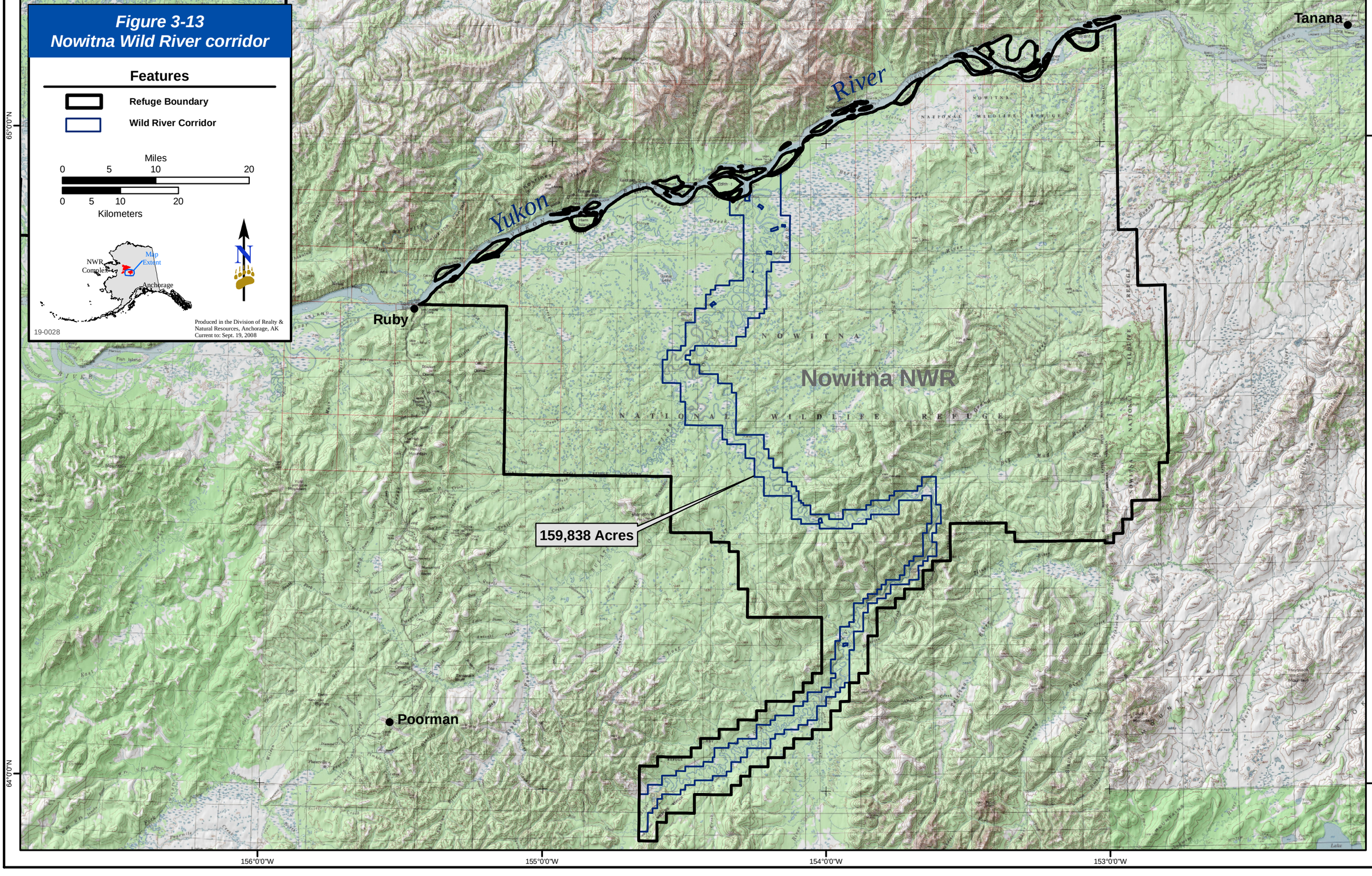
These are the waterways or sections of waterways on public lands that are readily accessible by road or railroad, may have some development along their shorelines, and may have undergone some impoundment or diversion in the past.

All eligible rivers on the Refuge would be categorized a wild as there are no roads, impoundments, or diversions affecting rivers within the Refuge.

3.6.2 River Values

The Wild and Scenic Rivers Act (U.S. Congress 1968) provides for the protection of rivers of the nation that are found to possess at least one unique, rare, or exemplary feature that is significant at a regional or national scale. Guidelines were developed by the Interagency Wild and Scenic Rivers Coordinating Council to provide greater consistency in identifying "outstandingly remarkable values" (Diedrich and Thomas 1999). They illustrate minimum thresholds to establish "outstandingly remarkable values" but are not all-inclusive and should be adapted to suit specific areas under consideration. Descriptions of the categories of "outstandingly remarkable values," as developed informally by refuge staff consistent with national general guidelines, are described in the following text.

Figure 3-13
Nowitna Wild River corridor



3.6.2.1 Scenery

Landscape elements such as landform, vegetation, water, color, and related factors provide exemplary scenery and visual attractions over most of the river or river segment. Factors such as seasonal variations in vegetation, or visibility, size, and appropriateness of cultural modifications may be considered.

3.6.2.2 Recreation

The river or corridor possesses recreational opportunities that are unique or rare within the region, and may be popular enough to attract visitors from throughout the region and beyond. River-related recreational opportunities could include wildlife viewing, motor-boating or floating, camping, photography, hiking, fishing, and hunting.

3.6.2.3 Wildness

Wild rivers are natural and undeveloped (free from the effects of modern civilization), and provide opportunities for solitude and primitive and unconfined types of recreation.

3.6.2.4 Geology

The river or corridor contains a geologic feature or process that is unique to the region. The feature may be in an unusually active stage, represent a "textbook" example, or embody a unique or rare combination of geologic characteristics.

3.6.2.5 Fish

The river provides exceptionally high quality habitat for fish species of the region and/or is an important producer of resident and/or anadromous fish populations. Of particular significance is the presence of rare, threatened, endangered, or sensitive species. Diversity of species and habitats is also an important consideration.

3.6.2.6 Wildlife

The river or corridor contains nationally or regionally important populations of indigenous wildlife species and/or provides exceptionally high quality habitat for wildlife of national or regional significance. Of particular significance are species considered to be unique and/or populations of rare, threatened, endangered, or sensitive species. Diversity of species and/or habitats may also be of remarkable quality.

3.6.2.7 Cultural Values

The river or corridor contains an area significant to traditional cultures. Examples might include sites that support traditional activities or religious ceremonies.

3.6.2.8 History

The area contains a site or feature associated with a significant event, an important person, or a cultural activity of the past that is unique to the region. Historic sites and features are generally defined as 50 years old or older, and may be listed on the National Register of Historic Places.

3.6.2.9 Prehistoric Values

The river or corridor contains an area important for interpreting human prehistory, including sites of archaeological significance. Sites must have unique or rare characteristics or exceptional human interest value.

3.6.2.10 Other Values

No specific national evaluation guidelines have been developed for the "other similar values" category, but other river-related values such as hydrology, paleontology, and botany may be considered.

3.6.3 Rivers and River Segments

In interior Alaska, rivers provide vital habitat and function as important travel corridors for wildlife and people. Rivers support subsistence activities and attract recreational users interested in fishing, hunting, boating, and wildlife observation. Fish and wildlife travel and feed in and along rivers and rear young in associated terrestrial habitat, ponds, and wetlands.

The following qualities are common to all refuge rivers and meet classification criteria for Wild River designation under the Wild and Scenic Rivers Act (U.S. Department of the Interior, U.S. Department of Agriculture 1982):

- All rivers within the Refuge are free-flowing and free of impoundments.
- Shorelines are primitive, with little or no evidence of human activities. Trapline cabins and fish camps are generally the only developments along rivers, are fairly uncommon and inconspicuous, and are culturally and historically appropriate for the region.
- Rivers are generally inaccessible by land, with no provisions for vehicle travel within the river area and few trails.
- Water quality meets or exceeds levels necessary for aesthetics and propagation of fish and wildlife using the river.

Below is an inventory of free-flowing rivers or river-segments located within the Refuge. Based upon known river qualities, Table 3-14 is a list of rivers evaluated by refuge staff for outstandingly remarkable values. Appendix K lists all of the rivers examined.

Table 3-14. Rivers examined.

Refuge	River Considered
Koyukuk	Billy Hawk Creek
Koyukuk	Cottonwood Creek
Koyukuk	Dakli River
Koyukuk	Dulbi River
Koyukuk	Dulbi Slough
Koyukuk	Gisasa River
Koyukuk	Hogatza River
Koyukuk	Holtnakatna Creek
Koyukuk	Huslia River (north and south forks)
Koyukuk	Indian River
Koyukuk	Kateel River
Koyukuk	Koyukuk River

Refuge	River Considered
Koyukuk	Little Indian River
Koyukuk	Natlaratlin
Koyukuk	Nayuka River
Koyukuk	Nulitna
N. Unit Innoko	Bishop Creek
N. Unit Innoko	Bonanza Creek
N. Unit Innoko	Eddy Creek
N. Unit Innoko	Gorton Creek
N. Unit Innoko	Green Water Creek
N. Unit Innoko	Kaiyuh Slough
N. Unit Innoko	Khotol River
N. Unit Innoko	North Creek
N. Unit Innoko	Soonkakat River
N. Unit Innoko	Squirrel Creek
N. Unit Innoko	Tsurotlurna slough
N. Unit Innoko	Wounded Cub Creek
N. Unit Innoko	Yukon Creek
Nowitna	Bering Creek
Nowitna	Big Creek
Nowitna	Big Mud River
Nowitna	Blind River
Nowitna	Deer Creek
Nowitna	Grand Creek
Nowitna	Junekaket Creek
Nowitna	Klatsuta River
Nowitna	Little Mud River
Nowitna	Our Creek
Nowitna	Sethkokna River
Nowitna	Sulatna River
Nowitna	Sulukna River
Nowitna	Susulatna River
Nowitna	Titna River
Nowitna	Yukon River

The following rivers or river segments were informally identified by Refuge staff as having exceptional values.

KOYUKUK

Billy Hawk Creek - Outstandingly Remarkable Values: Wilderness, Wildlife, and Fish

Billy Hawk Creek is a tributary to the Huslia River. Its headwaters lie in the Purcell Mountains a few miles north of the northeast corner of the Koyukuk. This stream flows over refuge land for most of its length. This creek is difficult to access even by floatplane, and as such, provides recreation opportunities in a wilderness setting where solitude is of a degree uncommon to other areas of the refuge. The river is one of the major chum salmon spawning areas on the Koyukuk. Bears opportunistically feed on spawned-out chum salmon, other wildlife, and vegetation in the corridor. Tracks and scat of brown and black bear, lynx, wolf, wolverine, beaver, river otter, and other mammals are commonly found along the river, though actual observations are less so. During the summer months, common birds on the river include White-fronted geese, Lesser Canada geese, swallows, and numerous species of ducks.

Dakli River - Outstandingly Remarkable Values: Scenic and Wildlife

The Dakli River originates in the southwestern flanks of the Zane Hills and flows south over the northern boundary of the Refuge, joining the Koyukuk River on one of its northern meander bends. The broad river valley provides panoramic view of the Purcell Mountains and the Zane Hills. The valley is used every winter by some of the Western Arctic caribou herd. The Dakli River is the traditional caribou hunting area of people from Huslia.

Dulbi River - Outstandingly Remarkable Values: Scenic, Wildlife, Cultural, and Historic

The Dulbi River headwaters are near Hochandochtla Mountain on the southeastern border outside the Koyukuk. It flows much of its 121 miles southwesterly outside the Refuge near the boundary and then turns northwest about 50 miles from its headwaters and crosses into the Refuge. The lower section of the river has a high moose density. Moose commonly feed on the willows along the river. Bears opportunistically feed on fish, other wildlife, and vegetation in the corridor. Tracks and scat of brown and black bear, lynx, wolf, wolverine, beaver, river otter, and other mammals are commonly found along the river, though actual animals observed are less so. During the summer months, common birds on the river include White-fronted geese, Lesser Canada geese, swallows, and numerous species of ducks. The river is a major breeding and molting area for waterfowl. The Dulbi River is important to the villages of Huslia, Galena, and Koyukuk for waterfowl hunting, moose hunting, and trapping. Several abandoned villages and sites that are important to Alaska native history are located along the Dulbi River, including Hadokhten and Dalbi Village.

Gisasa River - Outstandingly Remarkable Values: Historic and Fish

Gisasa River flows 70 miles southwest to northeast, from its headwaters in the Nulato Hills to its mouth at the Koyukuk River in the southwest corner of the Koyukuk. Only the lower third lies within the refuge. The river is important for anadromous fish (Chinook and chum salmon) and resident northern pike. The Fairbanks Fishery Resource Office, U.S. Fish and Wildlife Service, maintains a fish counting weir on the lower portion of this river. The Gisasa River is important to the village of Koyukuk for moose hunting and winter trapping. A historic village site was located at the river mouth that is important to Alaska Native history.

Hogatza River - Outstandingly Remarkable Values: Scenic, Wilderness, and Historic

The Hogatza River flows 120 miles southwest, from its headwaters in the foothills of the Endicott Mountains to its mouth at the Koyukuk River on the northern border of the Koyukuk. The Hogatza River is a meandering clear water stream subject to frequent high water events. This river is difficult to access even by floatplane, and as such, provides for recreation opportunities in a wilderness setting where solitude is of a degree uncommon to other areas of the Refuge. Travel along the river provides spectacular views of the east side of the Zane Hills. The river contains the Hog River landing site, which is part of the area's mining history.

Kateel River - Outstandingly Remarkable Values: Scenic, Fish, and Historic

The headwaters of the Kateel River lie in the Nulato Hills. The river flows northeast and then southeast for 115 miles before joining the Koyukuk River just inside the western border of the Koyukuk. Only the southeastern trending portion of the river lies within the Refuge. The Kateel River has two major tributaries: Aravesta Creek in the Nulato Hills outside the Refuge; and Honhosa River, which also originates in the Nulato Hills outside the Refuge but flows nearly half its length inside the Refuge. Floating down the river provides varying views of a narrow river valley and an outstanding experience of wildness, as the river twists and turns through this unusually narrow river valley. The river is important for anadromous fish and resident northern pike. The Kateel River is an important chum and Chinook salmon spawning area. A historic village site was located at the river mouth that is important to Alaska Native history.

Koyukuk River - Outstandingly Remarkable Values: Scenic, Wilderness, Fish, Wildlife, Historic, and Prehistoric

The headwaters of the Koyukuk River are at the confluence of its Middle and North forks near Bettles. From these headwaters, the river flows 424 miles to its mouth at the Yukon River. The river is a major natural landmark on the Refuge, meandering 300 miles across the refuge from northeast to southwest. The river commonly floods during spring runoff and occasionally after high intensity fall rains. The river contains 20 species of fish, including salmon, cisco, sculpin, lamprey, whitefish, northern pike, Dolly Varden, and sheefish. The river is a crucial migration corridor for anadromous fish, including Chinook and chum smolt heading downstream to the ocean and adults returning upstream to spawn. The river corridor, with its abundant willow, provides critical habitat for moose. The Koyukuk River corridor has one of the highest moose population densities in the state—up to 12 moose per square mile. The river is used extensively by the villages of Koyukuk, Huslia, and Hughes for fishing, hunting, trapping, and transportation. The river is used in the summer months to barge goods and fuel to the three villages. Numerous historic villages and archeological sites (some dating back over 10,000 years) are located along or near the river and are important to Alaska Native history.

Little Indian River - Outstandingly Remarkable Value: Historic

The Little Indian River drains an uplands area adjacent and east of the Koyukuk. The headwaters of the river lie just outside the Refuge. The river flows for most of its length in the Refuge. Batza Tena is one of the few known obsidian sources in Alaska. Batza Tena played a significant role in cultures inhabiting the area during the last 10,000 years, as well as aboriginal cultures as far away as central Canada. Also located near the river is the "Trading

Place," reported to have been the traditional location where Kobuk Eskimos would announce their arrival to local Koyukon Indians in order that trading activities might commence.

Northern Unit Innoko

Kaiyuh Slough - Outstandingly Remarkable Values: Hydrology, Fish, Wildlife, and Recreation

Kaiyuh Slough is a 25-mile long waterway with unique hydrologic properties. The Slough connects lakes on Kaiyuh Flats and the Khotol River with the Yukon River. During part of the year when the Yukon River water level is higher than the water level on Kaiyuh Flats lakes, the slough serves as an inlet to the lakes and the Khotol River from the Yukon River. When the stage of the Yukon River is below that of the lakes, the slough can serve as an outlet for the lakes. In this case, flow direction will reverse. Kaiyuh Slough lies entirely within the refuge. This natural function helps create the habitat required by waterfowl and many other species. The slough has the highest beaver population in the area with over 30 per square mile in some places. The slough provides ideal habitat conditions for large northern pike, which in turn provides for a great pike fishery. Several historic villages and archeological sites are located along the slough or in the connected lakes that are important to Alaska native history.

NOWITNA

Yukon River - Outstandingly Remarkable Values: Recreation, Geologic, Fish, Wildlife, Historic, and Pre-historic

The Yukon River commonly floods during spring runoff and occasionally after high intensity fall rains. The river is a crucial migration corridor for anadromous fish (Chinook, chum, coho salmon, and sheefish), including salmon smolt heading downstream to the ocean and adults returning upstream to spawn. Many of the islands found within the river provide critical winter moose habitat. The river is used extensively by people for transportation, fishing, hunting, and trapping. The river is used in the summer months to barge goods and fuel to villages up and down the river. Several historic villages, archeological sites, and the old telegraph line (from the 1890s) are located along the river—all of which are important to Alaska and Native history. Along a seven-mile stretch of the Yukon River sits an area of frozen silt bluffs known as the Palisades or the "boneyards." This area is home to the remains of ice age animals and plants, making the Palisades both unique and an extremely important component for understanding this area's prehistoric past.

3.7 Refuge Infrastructure and Administration

3.7.1 Administrative Facilities

The Refuge is administered out of the headquarters office located in Galena. The Galena facility consists of an office building and warehouse/maintenance shop which is leased from Gana-A' Yoo Limited, an airplane hangar located on State-owned property adjacent to the Galena airport, and a storage yard/gas facility located on State property situated on the old Galena Air Force Base. The Refuge owns eight homes scattered throughout the city and one duplex located on the old Air Force Base. There are two seasonal floatplane docks—one located on Alexander Lake behind Service Quarters #3 and the other on the Yukon River in front of the office.

159°0'0"W
158°0'0"W
157°0'0"W
156°0'0"W
155°0'0"W
154°0'0"W
66°0'0"N
65°0'0"N

Dakli River
Hogatza River
Hughes
Billy Hawk Creek
Koyukuk River
Huslia
Dulbi Slough
Little Indian River
Nogahabara Sand Dunes
Wilderness
Nayuka River
Kateel River
Koyukuk NWR
Gisasa River
Koyukuk River
Natlaratlen River
Dulbi River
Koyukuk
Yukon River

Figure 3-14
Koyukuk River Values

Features

Refuge Boundary

River Values

Miles
0 5 10 20
0 5 10 20
Kilometers

NWR Complex
Map Extent
Anchorage

19-0013

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: Sept. 19, 2008

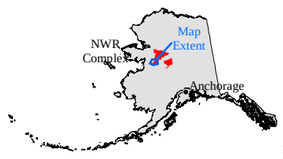
Figure 3-15
Northern Unit Innoko River Values

Features

Refuge Boundary

River Values

Miles
0 2.5 5 10
0 2.5 5 10
Kilometers



19-0012

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: Sept. 19, 2008

159°0'0"W
158°0'0"W
157°0'0"W

Koyukuk
Nulato
Galena
Kaltag
Northern Innoko NWR (Kaiyuh)
Squirrel Creek
Soonkakat River
Bishop Creek
Gorton Creek
Green Water Creek
Wounded Cub Creek
Bonanza Creek
Kaiyuh Slough
Khotol River
Eddy Creek
Tsurotlurna Slough
North Creek
Yukon Creek
Yukon River
Nulato River
Ninemile Island
Halfway Island
Koyukuk Island
Koyukuk Mountain
Notakok Mountain
Tamantaloi Hill
Pilot Mtn
Dyson Mtn
Serpentine Island
Bishop Rock
Prospect Point
Megotsol I
Fall Camp Lake
Mountains

Figure 3-16
Nowitna River Values

Features

Refuge Boundary

River Values

Miles
0 5 10 20
0 5 10 20
Kilometers

19-0014

Produced in the Division of Realty & Natural Resources, Anchorage, AK
Current to: May 13, 2008

156°0'0"W
155°0'0"W
154°0'0"W
153°0'0"W
65°0'0"N
64°0'0"N

Yukon River
Yukon River
Klatsuta River
Blind River
Little Mud River
Bering Creek
Deer Creek
Junekaket Creek
Grand Creek
Big Creek
Big Mud River
Nowitna River
Titna River
Titna River
Sethkokna River
Sulukna River
Our Creek
Sulatna River

Tanana
Ruby
Poorman

Nowitna NWR
NATIONAL WILDLIFE REFUGE
NOWITNA

The Hog River and Gisasa Weir administrative cabins are located on the Koyukuk. The Round Lake and Lower Nowitna administrative cabins are located on the Nowitna.

Four radio repeater sites are located on refuge land: Roundabout Mountain and Tough Mountain on the Koyukuk; Totson Mountain on the Northern Unit Innoko; and Hill 2321 on the Nowitna. There is only one leased radio repeater site, Kokrines, which is on BLM land and serves the Nowitna. Each repeater site consists of a structure enclosing a radio and battery bank.

3.7.2 Staffing

The current staffing at the Refuge consists of 14 permanent positions. The Refuge occasionally hires temporary biological technicians and maintenance helpers, Student Career Experience Program personnel, and other student program participants. The Refuge has a volunteer program that involves up to six individuals annually.

Current authorized refuge staff includes:

Wildlife refuge manager

- Deputy wildlife refuge manager
  - General biologist – subsistence
    - Refuge information technician
  - Administrative support assistant
  - Refuge clerk
  - Park ranger
  - Maintenance worker

- Supervisory wildlife biologist/pilot
  - Wildlife biologist
  - Wildlife biologist/GIS specialist
  - Airplane pilot

- Law enforcement/park ranger

- Fire management officer