

## Chapter 5: The Natural Environment



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### OVERVIEW OF THE RECREATION AREA

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The Chena River, paralleled by Chena Hot Springs Road, forms the spine of the area, providing a free-flowing clear-water stream for grayling fishing, salmon viewing, boating, river floating, camping and a variety of associated recreational opportunities. Landforms flanking the river valley rise to panoramic alpine ridges, the highest of which, Chena Dome, is 3,700 feet above the river valley. In summer, the Stiles Creek, Chena Dome, Angel Rocks and Granite Tors areas are major hiking attractions. In winter, the area provides excellent opportunities for snowmachining, cross-country skiing, skijoring and dog mushing, especially in the lowlands adjacent to streams.

This chapter describes the natural environments within the Recreation Area and Chapter 6 describes the human environment.

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### CLIMATE

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The Chena River Valley has a distinctly continental climate characterized by large seasonal variations in temperature and daylight. The area experiences cold, dry winters and warm summers, with more than half of the annual precipitation falling from June through September. The large mountain ranges lying to the south of the basin form an effective barrier to the flow of maritime air from the North Pacific for most of the year. The area receives as much as 22 hours of sunlight per day during June and as little as 4 hours per day in December.

The mean annual temperature for the Recreation Area is 27° F. The coldest month is January with an average temperature of -9.8° F and the warmest month is July with an average 60.0° F. Strong temperature inversions persist through the winter as cold air drains into low lying areas and remains trapped at valley level, while elevated locations are considerably warmer. Temperatures of -40° F or colder occur on an average of 10 days each winter, with an all time record low of -66° F recorded nearby in Fairbanks on January 14, 1934. Temperatures climb above 80° F about 9 days each summer, with the all time record high of 99° F occurring on July 28, 1919, in Fairbanks.

The Recreation Area receives an average of 15 to 25 inches of precipitation annually. The distribution of precipitation is highly variable due to the mountainous terrain, with the most significant amounts falling at higher elevations. The seasonal average of snowfall across the basin ranges from about 70 inches at valley level to over 100 inches at the higher elevations. The snowpack builds through the winter months and reaches a maximum depth during March. The snowpack generally persists for six to seven months. Rainfall typically comes from brief afternoon showers and thunderstorms from late May through mid July, leaving the majority of the summer warm and sunny. Upper level winds shift to the southwest in late July and bring moisture from the Bering Sea and North Pacific and result in frequent weather fronts moving across the area. August is the wettest month of the year with two to five inches of precipitation on the average in the Chena Basin. The average rainfall tapers off in the fall.

Throughout the Recreation Area local winds are influenced by topography and vary greatly in direction and intensity throughout the year. The prevailing wind direction for all seasons is from the northeast, with the strongest winds occurring during the winter over higher terrain and in channeled areas. While winds in excess of 60 mph are not uncommon at higher elevation, it's not at all uncommon for air to remain nearly still along the valley bottoms. As a result, ridges are often bare of snow in midwinter and cannot be depended on for snowmachining. Winds are more variable in summer and are influenced by differential solar heating of the mountainous landscape.

The extreme winter and summer climatic conditions heavily influence the visitation rates and the visitor activities. Summer's long daylight hours and warm temperatures enhance recreation opportunities and increase the number of overnight stays related to camping, hiking and river use. In mid-winter, long periods of limited daylight and extreme low temperatures restrict recreation activities in the Recreation Area to primarily day use. When the sunlight and relative warmth return around mid-February, visitation increases again, particularly for trail use and overnight stays at public use cabins. Opportunities to use the Recreation Area's trails are greater in winter due to frozen ground and snow cover.

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## **LANDFORMS AND GEOLOGY**

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As seen from Chena Hot Springs Road, the main landforms of the area are river valleys, often broad and flat, bounded by bluffs and low, rolling hills, which gradually build up to the high alpine areas. Viewed from the air, or the high trails, the Recreation Area is seen as part of a seemingly endless progression of rolling hills and dissecting streams interspersed with sporadic rock-crowned highlands.

The Chena River valley runs in a predominantly east-west direction. The valley profile is anchored by Chena Dome (4,421 feet) to the north and the Granite Tors (3,407 feet) to the south. On clear days the summits provide excellent views of the surrounding region, as well as Denali, 200 miles to the south. The river gradient on the upper stretch varies from eight feet-per-mile to eleven feet-per-mile. The gradient on the lower stretch of the river within the Recreation Area is approximately 3.5 feet-per-mile. A meandering flow, sloughs, gravel bars, wetlands and floodplain conditions characterize the river. Slope gradients in the Recreation Area vary from nearly level in the valley bottoms and on ridge tops, to over 40 percent on the bluffs and highlands (Map 5-1).

Variable depths of wind-blown silt covers most of the Recreation Area. These surficial deposits are locally rich in mammalian fossils.

Metamorphic rocks underlie most of the Recreation Area; south of the Chena Dome Trail these are low-grade, fine-grained, crumbly, largely metasedimentary rocks similar to those present along the south flank of Birch Hill in Fairbanks. These rocks are poorly exposed and form low, gentle, vegetation-covered slopes and ridges. Metamorphic rocks along and north of the Chena Dome Trail are of high metamorphic grade, commonly coarse grained, hard, well-layered and constitute most of the highest ridges and points (e.g., Chena Dome and Angel Rocks) in the Recreation Area. These rocks include gneiss and quartzite with lesser schist. They are commonly used for cairns marking trails in the region; coarse garnet is variably present.

Large granite bodies are present in the immediate Granite Tors area, along Angel Creek and at Angel Rocks. This rock is variably resistant to erosion and forms tooth-like "tors" up to 100-feet high. These projections are composed of less-fractured granite (resists erosion) surrounded by a sand of highly eroded, fractured granite. These tors are visible from many points in the Recreation Area and are an impressive attraction to hikers, skiers, photographers and rock climbers. The Angel Rocks body continues to the east beyond Chena Hot Springs and to the west along Angel Creek and the lower slopes of the Chena Dome Trail.

Smaller bodies of darker colored granodiorite and quartz diorite are present in the Tors Trail Campground area, both east and west of Chena Hot Springs Road. These bodies are usually covered by vegetation and their true extent is not known. One body of granodiorite immediately adjacent to the Tors Trail Campground is quarried and used extensively for rip-rap and coarse gravel in the region. Unlike the metamorphic rocks, rock from this quarry breaks equi-dimensional pieces ranging in size from large blocks to gravel. Because the body is poorly exposed it is not clear how much farther it extends beyond the present quarry.

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## **MINERAL RESOURCES**

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The Recreation Area has been closed to mineral entry by a state administrative order that determined mining as an incompatible use. Small amounts of placer gold were produced from Nugget Creek, Beaver Creek and Pine Creek, near the southwest edge of the Recreation Area and from Colorado Creek near the west-central edge. The Nugget Creek (South Fork) and Colorado Creek trails are derived from access trails to these placer mining sites. The only known lode prospect in the area is the Munzie (gold) lode in Section 34, T2N; R6E; FM above Colorado Creek, with claims maintained from 1971-1984.

Three prospecting sites, filed in 1996, occur in the northern portion of T2S R7E; FM, near the southwest edge of the Recreation Area. These prospecting sites total 480 acres. Although these sites are located within the legislatively defined boundary of the Recreation Area, the lands on which they are located are still in federal ownership and closed to mineral

entry (see Map 6-1). Mining cannot occur at these sites until the Bureau of Land Management conveys the land to the state. Mining activity is also taking place just outside the Recreation Area boundary on the East Fork of the Chena River. Access to this mining area has been through the Recreation Area.

## **MAP 5-1: SLOPE ANALYSIS**

## SOILS

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Four main soil associations are found within the Recreation Area. There are two soil types in the alluvial bottomlands and floodplain. The Tanana-Goldstream Association, an older soil, is poorly drained, permafrost laden and not suitable for development. The Salchaket Series consists of nearly level, well-drained soils that originated from water-deposited material along the Chena River. The upper layers are predominantly sandy with layers of silty material, which are underlain by thick deposits of coarse sand and gravel. Stream laid gravels and frost-stabilized ground along the main river channel are some of the best-drained soils in the Recreation Area. These soils have no permafrost and are suitable for development. Erosion hazards may exist on other alluvial soils in the bottomlands, but do not exist on the Salchaket soils.

Two other soil associations are found in the hills and uplands of the Recreation Area. Goldstream-Saulich soils occur generally south and east of the Chena River, in narrow strips along tributary drainages and frequently at the base of steep north-facing slopes. These are usually on slopes of three to seven degrees, very silty "muck" soils, containing almost no sand, often many feet thick and containing permafrost. Their ability to support any development is very poor.

On the high, moderately steep to very steep (20°- 40°) ridges north of the river is the Gilmore-Ester Soil Association. Gilmore soils occur on warm south-facing slopes, have no permafrost and are suitable for light development. The Ester soils occur on the north facing sides of the high ridges, contain permafrost and are typically covered with a thick mat of mosses, lichens and low bushes.

The study area is within the discontinuous permafrost zone of Alaska. Within this region localized areas of continuous permafrost, which have high ice content, are found in the poorly drained areas of fine-grained sediment. Areas of sporadic permafrost are found in well-drained coarse sediment or bedrock areas. Slopes exposed to the south, ground areas under birch, aspen and white spruce stands and soil beneath the Chena River provide conditions where permafrost is least likely to occur.

Due to permafrost, the Recreation Area contains many areas of wet and poorly drained soil. Such boggy conditions are especially prevalent along the lower Granite Tors Trail. Lengthy portions of this trail require boardwalks to avoid creating erosion problems in these areas. Boggy areas along streams, such as Colorado and Angel creeks, are also susceptible to disturbance.

In 1974 the United States Soil Conservation Service completed a supplement to the Fairbanks Soil Survey for areas containing "soil interpretations for non-agricultural planning and development." These findings show that development and use restrictions due to soil properties range from severe to moderate throughout most of the Recreation Area. The supplement demonstrated that certain soil types in the Recreation Area have significant environmental constraints, particularly where permafrost is present. Development of structures, roads and trails on these soils requires careful planning. In some cases, where alternative locations exist, these developments should avoid such areas in order to avoid costly modifications and long-term maintenance problems.

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## WATER QUALITY

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The Chena River is unique. It is the only clear water river of such a length in Interior Alaska that is extensively road accessible. The productive grayling fishery is an indicator of its excellent water quality. Grayling fishing is one of the main attractions of the Recreation Area.

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## HYDROLOGY

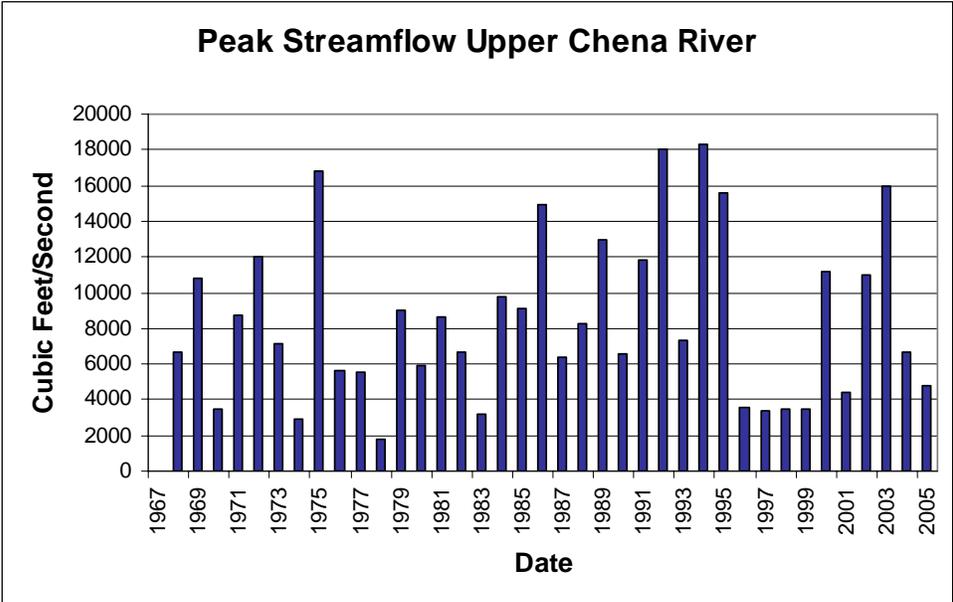
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A meandering channel characterizes the Chena River and drains the non-glaciated, mountainous region northeast of Fairbanks. It is estimated that as much as 50 percent of the Chena River Basin is underlain by permafrost (USACE, 1993). The presence of permafrost inhibits infiltration, thus increasing runoff. Stream flow patterns in the basin consist of high flows during the months of May through September and low flows from November through April. During the winter months, the Chena River and its tributaries are frozen over and the principle source of flow is from groundwater. As the groundwater storage is gradually depleted, the flow diminishes to a minimum in March or April. With the advent of above-freezing temperatures in April and May, the flow increases from snowmelt runoff and breakup of river ice. Peak flows generally occur in May or June, but can also occur between July and September as a result of widespread rainfall. The mean annual flow of the Chena River within the Recreation Area at the gauging station near Milepost-40 Chena Hot Springs Road is approximately 689 cubic feet-per-second (cfs). At this same location, the mean summer flow (open water, May-September) is approximately 1,328 cfs second and the mean winter flow (ice covered, October-April) is approximately 227 cfs second (US Geological Survey, with the period of record being 1968-2001).

Floods in the Chena River Basin result from a combination of rainfall and snowmelt. Major floods have occurred when a sudden rise in temperature combines with a warm rain on saturated snow cover. As a general rule, major floods will occur during spring breakup. When rain accompanies snowmelt runoff, floods have both high peaks and large runoff volumes. This is especially true when the ground is frozen (USACE, 1971). However, the most severe documented flood occurred in August 1967, when an exceptionally high peak produced record flows, which was the result of an intense widespread rainstorm over the Chena River Basin and adjacent watersheds. The record flood of 1967 had flows which exceeded a "one-hundred-year" flood event. Figure 5-1 shows the peak flows on the Chena River in the recreation area from 1967 to 2005.

Floodwaters add warmth to the ground, which promotes thawing of permafrost, which, in turn, can cause initiation of "thaw ponds" and areas of unstable topography. Thus large floods can cause substantial changes in topographical conditions, beyond just deposition of new alluvium. The most significant overall effect of floods is the cutting of new river channels and establishment of sloughs. The likelihood of periodic flooding along the main river channels must be considered in all phases of human activity in the bottomlands. In addition, the extensive permafrost and shallow bedrock areas of the upper Chena provide the ingredients for very rapid rises in water levels with heavy rains or warm spring weather. Any flooding can be intensified locally by log jams.

Figure 5-1: Peak Streamflow Upper Chena River, Courtesy U.S. Geological Survey



**FIRE**

Wildfires are a natural component of the ecosystem processes in interior Alaska. The Recreation Area has a history of such naturally occurring fires, as well as human-caused fires. Evidences of burns can be found many places within the area. Since 1950 approximately 85,982 acres of land within the area have burned. Since 2000, several wildfires have occurred: a small fire in Beaver Creek drainage and the relatively small Rock Creek fire in 2000 and the West Fork fire of 2002 that burned a portion in the north around Angel Creek. In 2004, the biggest fire season in recorded history in interior Alaska, the 30,800-acre Tors Fire consumed vegetation from most of the north slopes on the south side of the Chena Hot Springs Road between the East Fork and South Fork drainages. Thirteen miles of the fifteen-mile Tors Trail was burned. Map 5-2 shows the fire protection levels and fire history in the Recreation Area.

Fires reduce the vegetative cover and the surface albedo (reflection of sunshine), which results in warmer soils and deeper thawing of the permafrost layers. This can cause portions of the ground surface to either rise or subside, resulting in hummocky terrain. In following years the low spots may fill with ice and water and trees may tip as a result of the unstable conditions.

The black spruce woodlands of the Recreation Area are particularly susceptible to fire, due to their stand density, high percentage of dead lower branches and high pitch content.

Areas that have sustained fires in effect offer more stages within the forest growth cycle and therefore provide a more diversified habitat than mature forests. A forest with varying stages of growth is healthier and ultimately establishes more diversified wildlife. Also, some plant communities, depend on periodic fires for their survival.

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## **FIRE MANAGEMENT**

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The Department of Natural Resources, along with other state and federal agencies and Native corporations, has developed an interagency fire management plan for Alaska. This plan identifies the appropriate level of wildland fire suppression for all lands in Alaska. In some areas, wildland fires are actively suppressed to protect life, property, or valuable resources. In other areas, wildland fires are allowed to burn to improve wildlife habitat, decrease long-term risks of severe wildland fires and reduce the costs of fire suppression.

Critical Management Option areas have been identified where immediate and aggressive fire suppression efforts are taken to protect life and property. Critical Management Option areas are typically close to residential areas and cover less than one percent of the Recreation Area. Full Management Option areas also receive immediate suppression efforts to protect high value resources where fire may adversely impact resources. Full Management Option areas follow the major highways in the Tanana Basin, and where there are valuable resources close to access. Approximately nine percent of the Recreation Area is in a Full management Option area. Modified Management Option areas are those with high-value resources where land managers may consider trade-offs of acres burned versus suppression costs. Fires are attacked immediately, but land managers guide the suppression effort. Modified Management Option areas cover six percent of the Recreation Area. Limited Management Option areas are those where fire is beneficial or benign, or fire-fighting costs are greater than fire damage. In these areas, fires are monitored, but no suppression action is taken except to prevent fires from burning onto higher value land. Approximately 84% of the Recreation Area is in Limited Management Option areas.

Fire suppression levels are reviewed annually among the agencies and major landowners. Map 5-2 shows the current fire suppression levels within the Recreation Area. For additional information on fire management policies, see the Alaska Interagency Wildland Fire Management Plan.

During the 2004 fire season, a fire line was bulldozed from the Two Rivers Road, through the Tanana Valley State Forest and into the western edge of the Recreation Area. The fire line is open to year-round motorized or non-motorized trail use up to a specified point in the Chena River SRA. At that point, signs are posted and a large rock barrier is placed to restrict ORVs from using the Chena Dome Trail.

## **MAP 5-2: FIRE PROTECTION LEVELS AND FIRE HISTORY**

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## **WILDLIFE**

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Numerous wildlife species inhabit the Recreation Area, some as residents, some as migrants. The Alaska Department of Fish and Game publishes management reports on Game Management Unit and species type. Map 5-3 shows the 254,080-acre Chena River State Recreation Area within the 5,832,960-acre Game Management Unit 20B. The Recreation Area is roughly four percent of Game Management Unit 20B. Appendix E contains figures specific to species within Unit 20B.

Large mammals include moose, wolf and brown and black bear, all of which cover shifting territories according to season, snow cover and available food sources. Moose are common, year-round residents of the area. They frequently occupy the valley bottoms and slough ponds in the summer, but may move upward in the fall to the sub-alpine areas to feed on upland willows. Moose habitat also includes recently burned areas that contain willow and birch shrubs and along timberline plateaus. In winter, moose gather in groups and move to lower elevations to feed on willow along the rivers and sloughs. Because moose hunting season finds most bull moose in the upland drainages, the distances involved in packing out a moose have been a limiting factor to hunting. Park ranger observations indicate that most of the Recreation Area harvests are mainly young bulls along the road corridor.

In the past, the Fortymile caribou herd used the northernmost portion of the Recreation Area as summer range and calving area. In past years, the herd has reduced greatly in size and their range has also diminished and changed location. Their traditional range should be protected from any uses that might discourage the return of caribou to the area. In 1982, several thousand caribou wintered in the East Fork and Munson Creek area east of the Recreation Area. Since then, no caribou sightings have been reported within the Recreation Area until the fall of 2003, when several thousand found their way into and near the northern portion of the Recreation Area. Results from efforts to increase the Fortymile caribou herd have been successful. This increase can be attributed to management, private citizens action and favorable winter climate condition.

Brown bear habitat in most of Unit 20B is classified as low density, although the upper Chena and Salcha rivers have been classified as medium density. Fish and Game's Management Report estimates a brown bear density in this area to be approximately 16.1 bears per 1,000 square miles. Brown bears have been spotted in the Recreation Area. Hibernation occurs during the winter and can be anywhere from five to seven months.

Black bears are abundant and may be found in many habitats within the area. Fish and Game estimates, for the regulatory year 2000, a population between 750-1200 black bears in Unit 20B (the Recreation Area comprises four percent of Unit 20B). They are normally out of hibernation from approximately May 1 through October 1. During the spring and summer they frequent the lowland valleys, then spend August and September in the uplands, feeding primarily on berries.

Fish and Game 2003 Wolf Management Report states, "Wolf population size and harvest have varied considerably, both spatially and temporally, within this management area [Unit 20B]. Wolf numbers are primarily regulated by prey availability, but wolf control and harvest have periodically reduced wolf populations in portions of the management area." Unit 20B has an estimated 150-225 wolves and 20-30 wolf packs. This has been consistent since 1992.

Numerous smaller fur bearing species are found in the Recreation Area. Trappers utilize several of these. Furbearers are difficult to study due to their elusive behavior and diverse habits and habitats. Trappers have provided key information in the population estimates of these furbearers by answering Fish and Game questionnaires. Species within the Recreation Area include ground squirrel, red squirrel, snowshoe hare, river otter, beaver, marten, mink, weasel, red fox and lynx.

Many places along Chena Hot Springs Road afford excellent wildlife viewing opportunities. In a non-standardized count of wildlife observations conducted in 1997 by state park staff, many sites were identified, with the three prominent moose viewing areas being: Milepost 28; Milepost 33; and Milepost 42.8. These locations are at beaver ponds where moose congregate to feed. There are also opportunities to view salmon spawning at Milepost 47. Other possible wildlife viewing sites include: MP 27.8, 29.2, 29.4, 38.8, 39.1, 41.6, 42.0, 42.8, 46.0, 46.7 and 49.9.

## **MAP 5-3: GAME MANAGEMENT UNIT 20B**

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## **BIRDS**

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The Recreation Area supports a rich diversity of birds. At least 93 species of birds are known to breed in the area and approximately 35 other species can be found during spring and fall migrations. Represented in the area are waterfowl, shore birds, raptors and birds that inhabit the forests, brush and alpine areas.

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## **FISH**

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The Chena River is a rapid-runoff tributary to the Tanana River originating in the Tanana Uplands 90 miles east of Fairbanks. The river flows approximately 160 river miles from the uppermost reach in the East (Middle) Fork to the confluence with the Tanana River at Fairbanks. The Chena River watershed is about 2,000 square miles and includes five major tributaries: North Fork, West Fork, South Fork, East (Middle) Fork and the Little Chena River. Collectively, these major tributaries and the main channel are over 290 miles in length. The streams are transparent green at low water, but become stained with tannins during mild runoff events and become darker with silt and organic material during high water events.

The upper Chena River is accessible from the Chena Hot Springs Road within the Recreation Area beginning at Milepost 26, and intermittently at about 20 sites, until Milepost 48.9. This makes it a popular stream for fishing by Alaskan residents, visitors and fishing guides.

Among the 12 species of fish in the Chena River, the Arctic grayling is the most popular sport fish. Grayling spawning occurs in May, shortly after break-up, while the waters are naturally high and turbid. Spawning occurs throughout most of the river, except in the uppermost reaches. After spawning, many adult fish migrate further upstream to summer in the river's headwaters. Many adults and the developing young remain in the middle and lower river. In the fall most of the grayling move up or down the river to over-wintering areas outside the Recreation Area.

Fishing season on the Chena River is open all year. Reductions in grayling abundance, particularly larger fish, precipitated a series of regulation changes culminating in the fishery being restricted in 1993 to catch-and-release and unbaited, single hooks.

Round whitefish are occasionally caught on sport tackle in the Recreation Area. Humpback whitefish, burbot and northern pike are also present in much lower densities than in areas downstream outside the Recreation Area. They are rarely caught.

Chinook (king) and chum salmon spawn in the Recreation Area. The Chena and nearby Salcha rivers are the two most important chinook salmon spawning streams in the Yukon River drainage in Alaska. Although yearly spawning populations are variable, the salmon runs in the Chena have been increasing since the early 1980s. Escapements of close to 10,000 chinook salmon are not uncommon in the Chena River, with spawning abundance in

the river within the Recreation Area in the range of 5,000 to 7,000 during the peak in late July and early August. Typical abundance of chum salmon is unknown, but there are far more chum salmon than chinook salmon. Salmon fishing is closed in the upper section of the Chena River, including the entire river within the Recreation Area.

The Alaska Department of Fish & Game stocks three gravel pit ponds in the Recreation Area with arctic grayling and rainbow trout. The rainbow trout are sterile. These stocked ponds provide children and less experienced anglers easier fishing than the river. They also provide off-river opportunity for anglers when the river is high and turbid and during the winter. Other species found in the river and sloughs are long nose sucker, Arctic lamprey, least cisco and slimy sculpin.

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## VEGETATION

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The Recreation Area contains an unusual diversity of plant communities representative of interior Alaska, ranging from bogs and river bottomlands through hillside woodlands to high alpine tundra (Figure 5-4). The plant associations of the area vary dynamically with the interactions of soil characteristics, elevation, slope orientation to sun and wind, climatic and fire events, water drainage, river dynamics and location of permafrost.

The vegetation of the valley bottomlands, because of the constantly shifting river channels, is in a continual state of long-term dynamic succession. Freshly deposited alluvium is colonized by willow and herbs, which give way to the slower developing balsam poplar. At first, the poplars shelter, then give way after 50-75 years to white spruce, which may last up to 300 years. These stands of mature white spruce among the river meanders are the largest trees found in the Recreation Area. Eventually permafrost is established beneath their heavily shaded roots. This allows the development of black spruce and moss woodland, the final and most stable stage of the succession. When black spruce woodlands are disturbed by fire, the most prevalent agent of change, the underlying permafrost will thaw, warming the soil and the succession cycle starts again.

Slope aspect is the determining factor in the type and extent of woodlands covering the hillsides of the area. South-facing slopes generally support mixed woodlands of birch, aspen and white spruce, with an understory of prickly rose, highbush cranberry and other shrubs. The north-facing slopes, underlain by permafrost, are covered with black spruce forest, with occasional birch and tamarack and a thick ground cover of mosses, lichens, Labrador tea and low-growing berries.

Of all the vegetative communities, black spruce woodlands are the most susceptible to fire, due to the high amount of dead branches close to the ground and the thick mat of mosses and lichens.

The alpine tundra is limited to the high ridges and hilltops around Chena Dome and the Granite Tors. With its open vistas, profusion of summer wildflowers and association with unique plants and geologic features, the high tundra is the most desirable destination for hikers and trail users.

High and low bush cranberries, blueberries, cloudberrries, raspberries and currants are abundant throughout the Recreation Area and berry picking is a popular activity for visitors and a major food source for wildlife.

## **FIGURE 5-2: CHENA RIVER VALLEY PROFILE**