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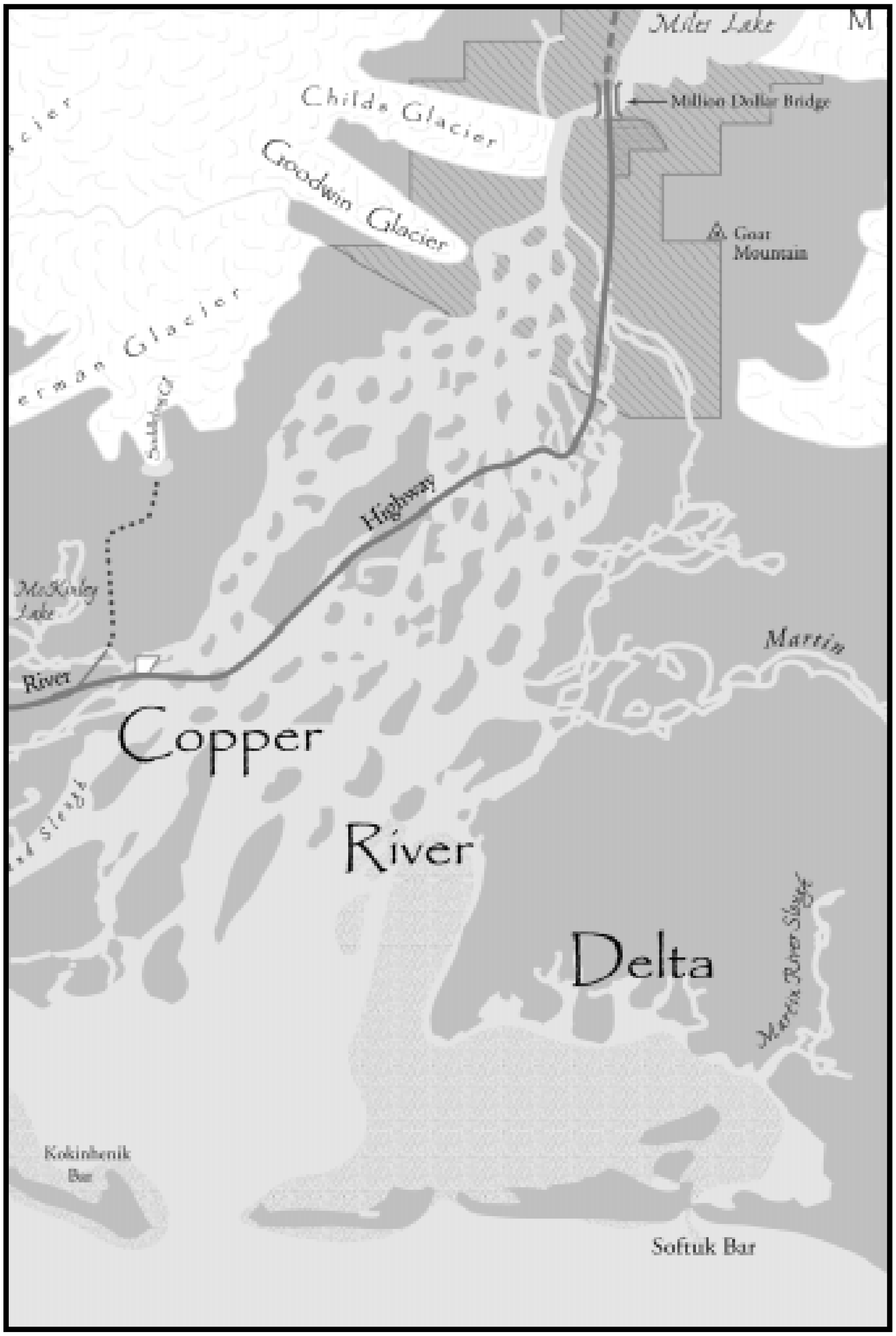
Alaska's Copper River: Humankind in a Changing World



Technical Editors

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See detailed map of the Copper River Delta in pocket on inside back cover.

Alaska’s Copper River: Humankind in a Changing World

Harriet H. Christensen, Louise Mastrantonio,
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Abstract

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Opportunities for natural and social science research were assessed in the Copper River ecosystem including long-term, integrated studies of ecosystem structure and function. The ecosystem is one where change, often rapid, cataclysmic change, is the rule rather than the exception. The ecosystem also contains a variety of people pursuing various human purposes. Although few people dwell in the ecosystem, their signatures are evident in many ways, and their numbers and effects are increasing. Thus, the Copper River ecosystem presents the opportunity to “watch creation,” in the sense of both natural change and human influence.

A multidisciplinary group of 16 scientists and specialists with a wide range of experience in natural resource science and education defined the Copper River ecosystem in scientific terms and described dimensions of the ecosystem including vegetation, wildlife, land ownership, and human occupation. Opportunities for science are described followed by recommendations. A section on “Knowledge as a Management Goal” also is included.

Keywords: Copper River ecosystem, science opportunities, natural and social science, integration, ecosystem structure and function.

Preface

One might ask, “Why the Copper River?” What can scientists and, by extension, society, hope to learn through research in a place as remote from the mainstream of 20th century society as Alaska’s Copper River? In addition to the primary questions asked of the Copper River Science Commission, we returned often to this essential question. Out of our discussions grew a theme that, we believe, explains the value of the proposed research program.

That theme is change—local, regional, global, ongoing change. As we met and deliberated, reinforced by divergent points of view and understandings of the environments around us, we became increasingly impressed by the life and vitality that mark the Copper River ecosystem. In contrast to many other “older” natural environments, rapid, cataclysmic change is the rule rather than the exception. Thus the idea of change as a theme for research.

It is a relevant theme not only because change is the nature of this ecosystem but also because of its importance in current society. Today, societies worldwide are experiencing unprecedented change because of population growth, advancing technology, and the shift from an agrarian to an urban society. The world is constantly evolving—the natural environment and human societies. Our future on the planet depends, in large part, on how successfully we adapt to change.

In addition, the Copper River is not so remote after all. As a region, it is as relevant and as connected to the whole as any part of our planet. The major glaciers of the world are a global water source and thermal “regulators” that help maintain ocean levels and establish climate. The region has been populated for more than 2,000 years and served as a “stepping stone” for people migrating across the ancient land bridge from Asia to North America. It also has been, over the years, an important source of natural resources and is currently an unparalleled attraction for tourists. Although few people live in the Copper River area, the human presence is felt in many ways. The Copper River presents a unique opportunity to watch evolution at work—to study the dynamics of environmental change, adaptation, and productivity. In doing so, we may help find answers to some of our most pressing natural resource problems:

- A changing global climate
- Long-term productivity of plant and animal resources
- Preservation of habitats for endangered and migratory species
- Reduction of the harmful impact of human societies on natural environments

Sometimes people use the term research to mean only traditional basic or applied research. We have used it here in a broad sense to mean different aspects of information gathering, including hypothesis testing, research, inventory, and monitoring, and to include many disciplines such as biology, ecology, geology, marine science, hydrology, sociology, and human history. This is especially important in an area such as the Copper River where relatively little “research” has been done, and the need for all kinds of information-gathering exists.

Research is one of the important ways we explain and understand our environment and our place in it. Research can provide the baseline from which to measure change, increase our understanding of the way ecosystems function, and learn much about the way people interact with their environment. Such information can help us make informed decisions about use and protection of natural resources.

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Contents

Background

This document is based on an earlier report (Gordon and others 1991) of the Copper River Science Commission, a multidisciplinary group of 16 scientists and specialists established in 1991 by the Forest Service. The commission was to serve in an advisory capacity as the Forest Service began to develop a long-term research program for the Copper River Delta region in Alaska. The commission was established jointly by the Copper River Delta Institute, Pacific Northwest Research Station (see “Appendix” for the history of the Copper River Delta Institute), and Alaska Region (Region 10) of the Forest Service in cooperation with the National Park Service.

The commission was asked to define the Copper River ecosystem in scientific terms and assess the opportunities for natural and social science research, with emphasis on long-term, integrated studies of ecosystem structure and function. The commission visited the Copper River Delta and parts of Wrangell-St. Elias National Park to share their ideas about this dramatic landscape and the potential for research. This document is a result of the commission’s discussions, subsequent efforts by several commission members, and an update of the science.

This document is not a comprehensive research plan as it is not possible to anticipate all the questions that could be asked about this area or to estimate what the ultimate value of research might be. Rather, this document is a framework for research. It sets a theme “humankind in a changing world,” as viewed from a remote, but important, part of the globe. It provides background information about the Copper River ecosystem, explores information and ideas, and suggests some potentially valuable areas for research.

Research, like ecosystems, is an evolving process. Questions are asked and explored in relation to the needs of a changing society, and answers to today’s questions lead inevitably to new areas of investigation. The research program that ultimately evolves from this effort may differ from that suggested here. Nevertheless, past research and our knowledge of current trends in society have provided useful clues and helped set the priorities for research outlined here. As needs change, priorities will change as well. The research program, as outlined here, should contribute substantially to our knowledge of natural ecosystems, both in the region and globally, and to our understanding of the role of human beings in an ever-changing world.

The Copper River Ecosystem

The Copper River ecosystem, located south and east of Anchorage in south-central Alaska, is a landscape of incredible scale and great natural beauty. At the northern edge, the Wrangell and St. Elias Mountains rise in snow- and ice-covered peaks to elevations of more than 16,000 feet. Out of the mountains, giant glaciers move slowly downslope, carving deep trenches and carrying along massive boulders, rocks, and tons of silt.

Out of the glaciers flow the headwaters of two major river systems, the Copper and Bering Rivers. Their tributaries include the Bremner, Chitina, Kennicott, Gulkana, and others. Flowing south and west, the Copper and Bering Rivers eventually spread out in a giant alluvial fan, the 75-mile-wide Copper River Delta. Here, their character changes dramatically, and the swift-flowing glacial torrents become winding ribbons of silt where they finally enter the Gulf of Alaska.

This giant river system, some 2 million acres, is a national treasure that includes major portions of Wrangell-St. Elias National Park and Preserve and the Chugach National Forest, as well as other public and private lands, some of which belong to the Alaska natives. This is a region of superlatives: It contains one of the world’s largest river systems, the most extensive coastal wetland on the Pacific Coast, and one of the most heavily glaciated regions in North America. The region also has a highly productive ecosystem with an abundance of shorebirds, waterfowl, and fisheries.

The Copper River ecosystem (see folded map in pocket on inside back cover) includes two distinct areas: the Copper River Delta and the much larger upper Copper River basin. Although geologically dissimilar, these two regions are ecologically inseparable and are linked by the Copper River canyon. The delta, in particular, takes its character from the glaciers and waterways that feed into it. Without the mountains, glaciers, and their erratic and turbulent waterways, there would be no delta.

Copper River Delta

The delta of the Copper and Bering Rivers is one of the largest coastal wetlands on the Pacific Coast, extending some 75 miles along the Gulf of Alaska from Hinchinbrook Island to the west to Kayak Island on the east. This is an area of relatively flat lowland, an outwash plain of gigantic proportions with a maze of constantly changing river channels, marshland, tidal flats, and sloughs that end in a series of offshore sand islands—a barrier reef that forms the outer margin of the delta.

Little is known about the geology and ecology of the near-shore waters of the Gulf of Alaska and Prince William Sound, although they are extremely productive, teaming with fish, shellfish, marine mammals, and shorebirds.

The delta is strongly affected by the erratic delivery of large volumes of water, sediment, and nutrients that enter the canyon from the upper basin. The wetlands are an interrelated complex of deltas and glacial outwash fans, the largest of which is the outwash plain and delta of the Copper River.

Drainage conditions on the delta fluctuate wildly because of large and seasonally varying tides, heavy summer rainfall, and the seasonal melt of upstream glaciers and snowfields. Beavers dam the quieter waters, further complicating the hydrologic cycle.

A History of Earthquakes

The delta exists in an exceptionally dynamic geomorphic and tectonic environment. Over the centuries, it has undergone repeated episodes of uplift, related both to volcanic activity of adjacent mountain groups and to movement of the offshore tectonic plates. The history of the delta over the past 2,000 years has been one of persistent subsidence punctuated at intervals of 600 to 1,000 years by violent earthquakes that result in uplift of about 6.7 feet. Evidence for this is based on radiocarbon-dated forest beds found exposed in the banks of Alaganik Slough and from samples taken from drill holes in which woody material is found in alternating layers with thick deposits of alluvium and tidal silt.

Uplift on the delta most likely leads to expansion of spruce and hemlock forest and other dry-land vegetation. Sediment brought downstream from the mountains, however, soon clogs and fills new channels and buries and drowns the forest. Thus, the Copper River Delta is in a state of dynamic equilibrium, which requires plants and animals to constantly adjust to environmental change.

The most recent uplift occurred in 1964 when an earthquake raised the delta about 6.7 feet, thereby producing a drastic retreat of the shoreline and new land at the outer edge of the delta. Streams and tidal creeks responded by cutting new channels and creating new areas of well-drained habitat along channel banks.

The delta adjusted rapidly to uplift. Within 15 years, the newly cut channels were filled and the river was once again flooding vegetated islands.

It is important to know how vegetation is affected by geology and how animal, including human, history is affected by both geology and plant ecology. Studies of the sequence of historical events that led to establishment and then destruction of forests of the delta will help us understand both the short- and long-term effects of earthquakes and to distinguish these effects from other environmental impacts.

An example is the recent invasion of alder in the delta and the resulting decline of forage for moose. This may be a result of overgrazing by moose, an introduced species, or it may be a delayed effect of the 1964 earthquake. If alder continues to increase in numbers along the now well-drained banks of newly cut channels, the moose population probably will decline over the next century or so.

Upper Copper River Basin

The Copper River begins its journey in a totally different environment than the delta—in headwaters and giant glacier systems far to the north and east. Here, the Wrangell and St. Elias ranges unite to create some of the highest, most rugged and spectacular mountain country in North America. The Wrangell Mountain includes six peaks of volcanic origin higher than 12,000 feet, with Mount Blackburn being the highest at 16,523 feet. Mount Wrangell is still active as evidenced by steam vents near its summit. It last erupted in 1930. To the southeast, and continuing into Canada, rise the St. Elias Mountains, a range of massive, isolated, blocklike mountains. Mount Bona at 16,421 feet is the highest point. This region has some of the largest glaciers in North America. Glaciers cover about 20 percent of the 13 million acres of Wrangell-St. Elias National Park and Preserve. Glaciers are of different sizes and types and differ dramatically in terms of ice accumulation and melt activity.

The climate of the upper basin is typically subarctic. Storm centers originating in the Aleutian Low move northeastward into the coastal mountains of Alaska. Interactions among these storms, polar highs, and the extreme of relief of the St. Elias region combine to produce some of the highest precipitation and temperature gradients in the Northern Hemisphere. Climatic conditions range from wet, warm, coastal-marine, to dry and cold in the interior. Consequently, the Copper River region is one of the highest priority sites in North America for studying the interaction between glaciers and climate.

Copper River Canyon

Between the delta and the upper basin lies the Copper River canyon, a desolate, ravinelike area that is basically a glacial outwash zone, consisting of a steep, narrow stream channel surrounded by massive boulders and rocks, perpetually subject to flooding and channel scouring. The canyon plays a major role in delivering massive quantities of water, sediment, and dissolved mineral nutrients to the delta.

Intermittent blockage of the canyon by glacial ice has magnified the environmental effects of the large climatic fluctuations of the Pleistocene and the smaller fluctuations of the Holocene epoch. During cold cycles of the Pleistocene, the canyon was completely blocked, and huge lakes were created in the upper headwaters of the Copper River. Subsequently, the lakes overflowed through Mentasa Pass to the Tanana River and into the Bering Sea to the west rather than into the Copper River system. Large amounts of sediment were captured in these lakes and then released after collapse of the glacial dams.

The much smaller glacial advances of Miles and Childs Glaciers during the past few centuries temporarily blocked the Copper River just upstream from the delta. The effect of this blockage on the hydrologic regime and the delivery of sediment and nutrients to the delta is not known.

The canyon also provides an avenue for migrations and dispersal of plants and animals from the subarctic taiga of the upper basin and the wet, temperate delta.

Vegetation

During the Pleistocene, the area of the Copper River was covered by glaciers, which began to recede around 14,000 years ago. Since then, plants have been steadily moving in from the south and from glacial “refuges” in Alaska and the Queen Charlotte Islands. Major tree species have become established in the last 4,000 years. Plant and animal migrations resulting from glacial retreat continue to the present.

In the Copper River ecosystem, various habitats produce a corresponding abundance of plant species, ranging from those that inhabit the outlying dunes to tidal flats, salt-water and freshwater marshes and ponds, and dry-land vegetation of forest and uplands.

A wetland classification system and map have been generated for the Copper River Delta based on SPOT satellite imagery, aerial photography, existing field notes, and ground truthing. Permanent sample plots have been established for observation of short- and long-term changes in plant communities.

A classification of community types, successional sequences, and landscapes of the Copper River Delta also has been created. A total of 75 community types, 42 successional sequences, and 6 landscapes has been described.

Common plant types include sedge, grass-forb, upland meadow, spagnum bog, muskeg, tidal marsh, dunegrass, willow and sweetgale, Sitka alder and understory plants, black cottonwood, and Sitka spruce.

Over the years, people have had an impact on the vegetation, although not to the ex-tent that has occurred in many other places. The major influences have been construc-tion of the Copper River and Northwest Railroad, built between 1906 and 1911, and the Copper River Highway, built 50 years later. These have altered waterflow and vegetation communities in the delta. How much they might have affected the area is unknown but could be studied through old photographs, field notes of early explorers, or oral histories.

Wildlife

The natural diversity of the lowlands and mountains of the Copper River ecosystem provides habitat for an abundance of animals, birds, and fish. Large mammals include moose, which were introduced beginning in 1949, black and brown bear, mountain goat, and Dall sheep. Smaller mammals include coyote, lynx, red fox, wolverine, wolves, porcupines, beaver, and squirrels.

Marine mammals also are found along the coast: Dall porpoises, harbor seals, sea otter, sea lions, killer whale, and humpback whales.

Fish

The Copper River supports the largest salmon fishery in central Alaska. Five salmon species and two char use the river. Copper River reds, the world famous “sockeye” salmon, have a global market. The sockeye have, over the years, separated into 19 or more stocks that use different parts and subbasins of the Copper River ecosystem at different times of the year. These subgroups do not seem to interbreed and are distinguished by their size and timing of return into the Copper River. The annual salmon runs attract large numbers of bald eagles, gulls, and bear, which gather to feed on the fish carcasses.

Freshwater fish are also abundant and include Dolly Varden char, arctic grayling, hooligan, burbot, and rainbow, lake, and cutthroat trout.

Birds

The Copper River region is home to more than 200 species of resident and migratory birds. These include sea birds such as black-legged kittiwakes, which nest by the thousands in colonies on the sea cliffs. Bald eagles are abundant and are commonly seen perched on snags or soaring aloft as they search for fish. Steller's jays are common in the rain forest as are ptarmigan in the alpine tundra.

Thousands of birds flock to the marshes and tide-swept mudflats of the Copper River Delta. In spring, the largest group are the shorebirds. As many as 5 million shorebirds stop here each spring on their migratory path. At least 20 shorebird species can be seen on the delta, but the most numbers are accounted for by just two species: the dunlin and the western sandpiper. Because the delta hosts more than 20 percent of the stopover population of these two species each spring, it has been designated a hemispheric site in the Western Hemisphere Shorebird Reserve Network. Other numerous shorebird species include the least sandpiper, red knot, sanderling, short-billed and long-billed dowitcher, common snipe, black-bellied plover, and the pectoral sandpiper.

The delta is also an important stopover and breeding ground for waterfowl, including nine species of diving and sea ducks and four species of dabbling ducks. Most numerous of the waterfowl migrants are the tundra swan, Canada goose, white-fronted goose, northern pintail, mallard, green-winged teal, and American widgeon. Sandhill cranes also flock on the delta during migration. After feeding and resting for a time, most of these birds continue on to breeding grounds farther north, but several thousand pair of waterfowl remain to breed and raise their young on the marsh wetlands of the Copper River Delta. For the dusky Canada goose, the delta is the only known nesting habitat. The delta also supports one of the larger known concentrations of nesting trumpeter swans (about 800 birds).

A Biogeographic "Bottleneck"

The Copper River canyon is a biogeographic "bottleneck" that connects the coastal rain forest and wetlands of the delta with the subarctic taiga and alpine tundra of the upper basin. Anadromous fish move through the canyon, but the turbid, turbulent waters have been a major barrier for many species, including moose. The rugged canyon has undoubtedly limited faunal and floral dispersals and exchanges, but its specific role and differential effects on species and population movements are not known.

In modern times, people also have greatly affected animal biogeography in the delta by introducting nonnative animal species. The most significant introduction on the delta was moose in the 1950s—an event that may have fundamentally changed plant and animal composition and abundance.

Land Ownership

Most of the Copper River ecosystem is in public ownership—the Chugach National Forest, managed by the Forest Service, U.S. Department of Agriculture (USDA), and the Wrangell-St. Elias National Park and Preserve, managed by the National Park Service.

The Chugach is the second largest National Forest in the United States and was one of the first Forest Reserves to be established (1907). National Forest lands are managed under a program of balanced resource use for the greater public benefit. Timber harvest is allowed as is mining, hunting, fishing, and other recreational uses. The delta is the only area in the entire USDA Forest Service system that is mandated (Alaska National Interest Land Conservation Act 1980) with a priority to manage for the conservation of fish and wildlife and their habitat.

Wrangell-St. Elias National Park and Preserve, a wilderness expanse of more than 13 million acres, is managed by the National Park Service as a nature preserve for public enjoyment and benefit. The area became a national monument in 1978 and a national park in 1980.

The park is managed on an ecosystem basis to preserve in their natural state extensive areas of arctic tundra, boreal forest, and coastal rain forest, and to maintain opportunities for scientific research and education. Park lands include a full range of natural and human history in Alaska, mighty landforms, and entire ecosystems. Certain units provide undisturbed natural laboratories, among them the Noatak, Charley, and Bremner River watersheds, which can serve as benchmarks to compare the effects of human activity on similar landscapes elsewhere.

Both the Forest Service and National Park Service are mandated, through enabling legislation, to conduct research, both to gather information in support of management programs and for public education purposes.

Human Occupation

People have been part of the Copper River ecosystem for centuries. Archaeological sites in the Prince William Sound region are at least 2,000 years old. Native Americans most likely came to the area much earlier, across a land bridge from Asia to North America, but the episodes of uplift and other natural changes have undoubtedly destroyed older dwelling sites.

Several groups of people have lived in the area. The upper Copper River basin is the traditional home of the Ahtna, an Athapaskan speaking people. The Copper River Delta is the traditional home of the Eyak, another group whose language is related to Athapaskan. Prince William Sound is the home of the Chugach. Their traditional territory extends almost to present-day Cordova, and they mainlined hunting camps farther east on what are now Middleton, Wingham, and Kayak Islands. Farther west are the Koniag, a large group whose territory extends from what is now Kodiak Island to Cook Inlet.

Along the coast, people were oriented toward sea resources. In the interior, they used resources from the rivers and hunted in the mountains. The cultures they developed provide excellent examples of the achievements of human beings who have adapted to challenging environmental conditions. They developed spiritual as well as economic relations to the environment, values that are readily apparent in rich legends and oral histories.

Long before the arrival of Europeans, the people of the Copper River had contact with each other and with neighboring groups. They exchanged ideas as well as trade goods, thereby making the region a rich center for cultural interaction. Some Chugach bowl and hat designs so closely resemble art styles of the Tlingit to the east that there is no question active interchange occurred. Stories recount trips of Chugach Indians up the Copper River to trade with the Ahtna, and sometimes to raid villages. Local resources, including copper and dentalia, were in great demand and were catalysts for trade, warfare, social relations, and other forms of cultural interaction.

The first contact between natives and Europeans occurred in 1741, when Vitus Bering's second Russian expedition reached Kayak Island. The people at that camp, probably Chugach, departed suddenly but reportedly left gifts, thereby indicating their awareness of the newcomers. By the 1780s, several European ships had explored Prince William

Sound. Considerable European activity occurred during that decade around Cook Inlet, and the people living in the Copper River region likely knew about these developments. In 1793, the Russians established a post near Nuchek. From there, they explored the Copper River and, in 1819, established Copper Fort near the confluence of the Copper River and the Chitina River.

As in other places in North America, contact with Europeans devastated the native populations. New diseases, demographic disruptions, military clashes, and mistreatment all contributed to rapid population declines. The region provides an opportunity to study demographic changes that occur when cultures mix. Certainly the history of the region is an example of the human ability to adapt to adversity.

Contact between native and nonnative people in the Copper River ecosystem was based primarily on trade until the gold rushes of the 1890s. Mining for other products, especially copper, began around that time, and Cordova was founded in the early years of the 20th century, originally on the site of an old Eyak village, as a railroad and shipping center for copper, which had been found near what is now Kennicott.

The mines brought a permanent nonnative population with business other than trading. The Copper River and Northwest Railroad provided the first developed transportation link from an ice-free tidewater port (Cordova) up the Copper River to the interior. This corridor was used until the railroads closed in 1938 because of the depletion of the copper mines. The nonnative population stayed, however, and Cordova developed into an active fishing town.

Natives of the region continued to live in traditional villages, but the coming of Europeans brought many changes. The introduction of Christianity has had an impact, as have new languages and new educational systems. The cash economy introduced by Europeans has changed native economies, and the establishment of nonnative towns and other developments has caused population shifts.

No treaties were made between indigenous people and either the Russians or Americans. In 1971, the U.S. Congress passed the Alaska Native Claims Settlement Act (ANSCA), establishing native regional and village corporations based on land ownership and economic development. From the mid-1970s on, there have been several studies of historical and cultural sites in the Prince William Sound area. The ANCSA has led to several conflicts concerning appropriate boundaries among lands claimed by native corporations, the state of Alaska, and Federal agencies such as the Forest Service.

The act is complex, and implementation has been difficult. Some problems are yet to be resolved; similarly, the relations among various Federal, state, cultural, and economic institutions in the region are under review. An understanding of the history of the natural and human components of the ecosystem, and knowledge about the impact of human activities on the ecosystem today are important to these valuations.

The Copper River area is home now to a small population comprised of both native and nonnative people. From the headwaters of the Copper River and its tributaries to the shores of the Gulf of Alaska and Prince William Sound, the resident population is found in several small communities, villages, and scattered homesteads.

Cordova is a center for commercial fishing and seafood harvesting associated with the Copper and Bering Rivers, Prince William Sound, and the Gulf of Alaska. All species of salmon are processed as are salmon eggs, halibut, black cod, tanner and Dungeness crab, razor oysters, herring, herring roe, and bait herring. In 1997, the combined salmon seine and gillnet fisheries from Prince William Sound generated $43 million in gross earnings for Cordova-based permit holders.

Cordova's tourism industry is growing at an estimated rate of 3 to 7 percent annually, possibly even higher. Fishing and hunting are the dominant activities, although many visitors also enjoy hiking, bird watching, mountaineering, river rafting, and sightseeing. The proposed historical and recreational 71-mile trail between Chitina and Cordova along the Copper River and Northwestern Railroad right-of-way may become a major tourist attraction. A 16-mile spur road will connect the main trail to the Richardson Highway along the Tiekel River.

The development of a deep-water port at Cordova will tap into the 200,000-passenger cruise and bus-tour market, with most of those people passing through nearby Anchorage, although passenger cruise ships started visiting Cordova in 1998. Anchorage residents and many of the estimated 70,000 visitors that arrive in Alaska in their own vehicles likely will use the Copper River highway if it is completed.

According to the Alaska Department of Labor, the Cordova population was 2,450 in 1990, including 44 Eyak natives. This likely will increase if or when the construction of the Copper River Highway happens, if the coal mines in the Bering River area and the Katalla oil field are eventually developed, through further development of the timber industry, and with new access into the eastern area of the delta. Many of the people of the Copper River engage in some form of business or commerce. Others survive entirely or in part through subsistence hunting and fishing. Lifestyle and quality of life are im-portant to Alaskans. People enjoy a lifestyle and quality of life not possible in many other places.

Science Opportunities

The Copper River ecosystem is increasingly valued as a place to read about, to study, and to visit—both by other Alaskans and by people outside the state. The delta has many attractions: a rugged landscape on a grand scale, a diversity of natural ecosystems, abundant waterfowl and wildlife, and a rich cultural history, including the native presence and the remnants of mines and mining towns.

The Copper River ecosystem is particularly well suited for interdisciplinary research that will increase our understanding of the way plants and animals, including humans, adapt to changing environments. The region has great environmental diversity in a relatively small geographic area and has undergone rapid rates of change over time.

Understanding the history of past change is critical to the study of adaptability. In the Copper River, the opportunity to study change is unparalleled. The legacies of geologic change include glacial retreat, earthquake-induced uplift, land subsidence, river fluctuations, and ocean sedimentation. It is also an excellent place to study human-environment interactions and human response to changing environments. Over the years, the natural resources of the area have been heavily used, for example, for logging, mining, hunting, fishing, and recreation; as a result, people have had to find new ways to make their living when some nonrenewable resources have been depleted.

Although the region has been relatively unaffected by human activities, two changes have considerably impacted the environment: construction of the Copper River and Northwest Railroad, built between 1906 and 1911 (now the Copper River Highway), which has changed drainage patterns and vegetation in the delta, and the introduction of moose, which has altered the natural patterns of vegetation succession.

Overall, however, the Copper River presents an excellent opportunity to learn more about ecological processes that have not been influenced greatly by humans, and to study the effects of future human use as the balance of influence between people and their environment shifts. This is especially important today when human activities are less defined by the ecosystem and have more of an intrusive impact on the environment.

The Copper River ecosystem is an especially good place to answer general questions about adaptability and response to change. Results of research will inform those who make management policy decisions and help determine whether policies are working as predicted and serving the changing needs of society.

Change, especially human-induced change, is often thought to produce only environmental degradation. But little is known about the factors that cause an ecosystem to be productive. The rapid change that characterizes the Copper River system may actually contribute to its high rate of biological productivity.

Potential Areas for Study

Organic productivity—The Copper River Delta discharges sediment and organic material into the oceans in amounts and compositions that change over time. The consumption and distribution of benthic fauna (those that live on the ocean or stream floor) are determined by these changes. Benthic fauna are important because they are at or near the bottom of a food chain that supports marine and aquatic life, birds, mammals, and humans.

The ability of organisms in the delta to adapt is limited by the speed with which sediments and organic matter are brought in. For example, the abundance of wood borers differs with the discharge of woody material, events such as uplift caused by earthquakes, or the discharge of water and sediment from glacially dammed lakes. Clues about the speed of adaptation may be found in woody material submerged in subtidal sediments at the seaward edge of the delta. Even if woody material is not preserved, the amount of organic matter and lignin in sediment cores may indicate the rapidity with which faunal adaptation has occurred.

The speed with which sediments are deposited could markedly change redox (oxygen flow) within the sediments and, therefore, the type and number of benthic fauna present. When sediment deposition is slow, organic production from the overlying waters may accumulate sufficiently to reduce redox. When sediment discharge is heavy, organic deposition would be diluted enough by sediment to reverse the situation. The idea is that the usual condition in which a high rate of sediment deposition leads to anoxic layers (those devoid of molecular oxygen) might be just the opposite in the delta.

Information about redox conditions would have many uses: one example is knowing how to treat an oil spill in the delta. The relation among hydrocarbons, glacial river sediments, and redox conditions in the deposition areas would determine the likely persistence of oil in the environment.

Plant-sediment-water interactions—The interaction among water, sediment, and plants controls the redox conditions in which plants grow. Soil redox, in turn, controls nutrient cycling, storage, and uptake by plants. Feedback links among these elements determine the productivity of plant and animal life.

Because the delta exhibits such dramatic variability in redox, we might assume that the plant microbial community is highly adaptable to various soil conditions. This is logical because the depth and distribution of sediments in the Copper River are in a constant state of flux. The waters are also cold, oxygen-rich and presumably nutrient-poor. Consequently, nitrogen may be more readily available, and redox may be higher than for river deltas at lower latitudes. Thus, plants may be able to grow in more water-logged conditions than they can at lower latitudes.

Plant productivity—Local economies are highly dependent on natural resources such as fisheries, timber, wildlife, and recreation. What many people do not understand, however, is that each of these resources is equally dependent on healthy, productive plant communities. Timber and wildlife resources are directly affected by the productivity and diversity of vegetation. A productive fishery depends on proper management of spawning grounds, streambanks, and nutrients provided by streambank vegetation and woody material. Recreation and tourism rely on beautiful, natural outdoor landscapes.

There are many opportunities for research beginning with studies to describe and define the major ecosystems of the Copper River. Other important topics include (1) developing an understanding of the physical and biological processes that "drive" plant succession, (2) monitoring vegetation changes over time by using remote sensing and ground studies, (3) relating vegetation changes to habitat for key wildlife species, (4) developing an understanding of the role of beaver impoundments in regulating ecosystem processes and structure of communities, and (5) developing better information about the aquatic-terrestrial interface and its relation to fisheries management.

Moose and plant productivity—Although moose consume large quantities of vegetation, their presence in the Copper River Delta may actually increase plant productivity. Moose prefer species such as willow and avoid alder and sweetgale, which are known to be nitrogen "fixers." The result is an increase in nitrogen-supported plant productivity. Increased nitrogen production could help fertilize willows, stimulate their growth and, in turn, provide more food for moose. If this is so, then management practices that remove competitors of willow may be counterproductive if they also remove nitrogen-fixing plants.

Habitat use by salmon—The productivity of anadromous fish in the Copper River system is an enigma in that heavily silted streams are believed to be poor habitat for fish. In the Copper River, however, that does not seem to be the case.

The complex hydrology and glacial activity of the Copper River has created a rich mixture of spawning and rearing habitats that are used differentially by different species and stocks of salmon. This diversity is highly dependent on two different climates—inland and coastal. In general, movement of fish and aquatic nutrient cycling are influenced by (1) spring and summer flooding of the mainstream Copper River and (2) coastal flooding because of rain and high tides during the fall-spring rainy season. These different phases bring in a constant supply of nutrients and may cause fish to disperse to different habitats.

To date, only preliminary studies have been conducted, and many questions remain unanswered. For example, What is the importance of freshwater habitats (beaver ponds and tidal sloughs) and outer marsh, shallow, estuarine habitats as rearing areas for juvenile salmon? What about the timing of juvenile outmigration, differences in survival and growth rates of juvenile fish in different habitats, and "fertilization" of beaver ponds by decomposition of dead fish? And what is the relative role of processes controlling productivity of these salmon stocks in the delta in contrast to the upper basin?

Effects of climate—Because of its latitude and the effects of constant cloud movement, the Copper River Delta is probably one of the most variable solar environments in the world. Consequently, it is an excellent place to study the effects of solar energy on biological productivity; for example, the differences between exposed sites and sites sheltered by dense vegetation. Automated weather stations should be established and snow surveys carried out annually.

Sediment and carbon budgets—The flow of sediment into the delta is strongly positive, meaning more sediment comes into the delta than leaves it. Some sediment is brought in from beaches by wind and waves, but most comes in by streams. Output consists mainly of delivery of sediment downstream to the Gulf of Alaska plus minor losses by wind and beach drift. Earthquakes periodically alter the patterns of erosion and sedimentation.

The carbon budget is probably also positive, with inputs coming primarily from plant growth or from driftwood and other organic material coming down the Copper River or being washed up by the sea. Exports consist of detrital carbon washed out to sea, carbon consumed by migratory fish and birds, and carbon dioxide and methane produced and released to the air by various organisms. Carbon is stored when organic matter is buried by sediment or when it accumulates as peat. Beaver dams also capture organic matter and build carbon deposits.

A knowledge of carbon and sediment inputs and outputs is basic to the study of productivity. Such nutrients are essential “food” for all life and building blocks of the food chain. Preparing carbon and sediment “budgets” for the delta would be an important early task for research.

Other Research Opportunities

Beyond the basic questions that relate to ecosystem productivity, many opportunities exist for research in the Copper River ecosystem. The following topics have been suggested by scientists as having high priority.

Geology and Geomorphology

Physical changes are constant in the Copper River ecosystem. Such changes include input of sediment into the delta, erosion by rivers and ocean tides and waves, changes in sea level, and alternating uplift and subsidence caused by earthquakes and movement of the offshore tectonic plates. Because they are both dramatic and sometimes abrupt, such changes have had a profound impact on plant and animal life. Research will help improve our understanding of north Pacific tectonic history, long-term climate trends, and human migrations. Such information is also necessary as a basis for sound management of fisheries and wildlife habitat and as a prerequisite to planning improvements such as roads, visitor centers, or other structures.

Research opportunities include:

- Tectonic history (uplift and subsidence) as evidenced by surface features and sedimentation along the delta
- Slope stability as influenced by climate and human activities
- Glaciation and its influence on early human populations
- Migration routes of early people
- Origin and evolution of the “barrier” islands at the mouth of the delta

Shorebird Ecology

The Copper River Delta is believed to have the largest spring concentration of shorebirds in the Western Hemisphere. In a given year, as many as 80 percent of the western sandpiper population passes through the Copper River Delta on their northward migration. Excellent opportunities exist to document long-term population trends, habitat use, and food habits of both the western sandpiper and Pacific dunlin, the two most numerous shorebirds of the Pacific Coast.

Whereas spring migration is relatively rapid, shorebird migration in fall is protracted and occurs from mid-June through October. To date, little is known about shorebird use of the delta during fall.

Studies on population monitoring and habitat use by shorebirds are also important because of the vulnerability of the delta to oil spills. The delta is close to oil tanker lanes, and there is also the potential for offshore oil and gas drilling in the Gulf of Alaska. In addition, in-formation on shorebirds will help in international efforts to develop conservation and management plans for the many species of shorebirds that use the delta.

Research opportunities include:

- Phenology, abundance, species composition, length of stay, and distribution of shorebirds using the Copper River Delta during spring and fall migrations
- Annual and interannual variation in migration strategies of medium-sized shorebirds including the Pacific dunlin and black-bellied plover
- Relation of the Copper River Delta to other shorebird stopover sites
- Habitat characteristics of areas heavily used by birds in relation to less used sites

Waterfowl Ecology

The Copper River Delta is an important summer breeding ground for many North American waterfowl, including the dusky Canada goose. Key to survival of many of these species includes maintaining healthy summer and nesting habitat as well as winter habitat.

Research opportunities include:

- Nutrient dynamics of dusky Canada geese in spring and summer
- Physical, biological, and chemical characteristics of freshwater habitats used by dusky Canada geese
- Timing, distribution, and abundance of staging waterfowl in intertidal and shallow subtidal habitats
- Spring and fall food habits of migrant sea and dabbling ducks

Wrangell-St. Elias Park and Preserve

Because Wrangell-St. Elias Park and Preserve was established relatively recently and because of its remote location, little research has been done there. Biological and ecological information is needed as a base for all resource management and protection activities and to support visitor education programs.

Research opportunities include:

- Long-term monitoring to establish baselines of plant community ecological structure and dynamics; wildlife aquatic systems; historical, anthropological, and archaeological conditions; and an opportunity to map local geology, soils, and landforms.

- Geology and hydrology of the Kennicott River basin. Dramatic events (avalanches, aufeis, failure of natural river dams, erosion, and landslides) are a threat to public safety and property in and around the Wrangell-St. Elias Park and Preserve. The towns of McCarthy and Kennicott, for example, can be reached only by a small footbridge across the Kennicott River. During floods, towns can become isolated, visitors can get stranded, and cars parked on the west side of the river could be damaged. Basic hydrological information is needed before visitor facilities and transportation systems can be developed.
- Learning about steelhead trout. The Hanagita and Tebay Rivers are the northern limit of steelhead trout. These fish are an important resource yet little is known about them—their numbers, biology, and ecology. Such information is needed to develop management strategies and priorities.

Watershed Hydrology

The Copper River is one of the most dynamic hydrologic systems in North America. The river basin drains about 24,000 square miles, has an average discharge of about 60,000 cubic feet per second, and transports some 60 million tons of suspended sediment downstream annually. Some of the world's largest ice sheets, notably the Bagley Icefield, are located at the upper reaches of the basin.

Research opportunities include:

- Glaciers as indicators of climate change
- Chemistry of glacial meltwater in relation to weathering products and sediment from glaciers
- Sediment characteristics—sources, quantity, and quality
- Establishment of "benchmark" stations on the Copper River and its tributaries to monitor water quality

Large Mammal Ecology

Large mammals are a major natural resource in Alaska. They provide food for subsistence and recreational hunting, contribute to the local economy and, because much of Alaska is undeveloped, are a major part of the regional ecology. Wild animals are part of the wilderness mystique and a boon to the tourist industry. Many opportunities exist to conduct ecological research on wildlife such as moose, wolves, brown and black bear, Dall sheep, and mountain goats.

The Copper River is a dividing line between land ownerships with different wildlife management objectives. The "minimum management" philosophy of the National Park Service contrasts with the management goals of the Forest Service and other agencies to maximize wildlife production.

Research can provide baseline data to compare the long-term results of these different management practices.

Research opportunities include:

- Ecology of gray wolves and wolf-prey relations
- Population dynamics of other large mammals: moose, Dall sheep, bear, and mountain goats
- Interactions among moose, beaver, and important forage plants
- Long-term succession in relation to habitat for moose

- Patterns of wildlife “recruitment” and mortality in relation to habitat change
- Moose as a case study of wildlife dispersal (in relation to the Copper River canyon)

Inventory and Monitoring

Certain types of baseline data are necessary as a foundation for management activities and other types of research. Key sites should be selected for long-term monitoring of vegetation. Monitoring would benefit other studies as well: hydrology, meteorology, human uses, stratigraphy (uplift history), archaeology, and human history.

Remote sensing should be considered because of the size of the region and can be used to assess vegetation changes, hydrology, sediment transport, and human alterations of the environment. Data gathering should be done at regularly scheduled intervals and with the cooperation of agencies such as the Forest Service, National Park Service, U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, National Marine Fisheries, and the U.S. Geological Survey.

Inventory and monitoring would be especially useful in gathering data on:

- Changes in forest and treeline in relation to global or regional climate change or vegetation changes as a result of human habitation or wildlife introductions
- Geologic-vegetation mapping. A geology map (scale 1:50,000) is needed for the entire Copper River ecosystem. It should include all geologic features and be tied to a vegetation map of the same scale
- Long-term monitoring of local hydrological conditions (snowfall, rainfall, streamflow, ground-water conditions, and evapotranspiration)

Social Sciences

Worldwide, people are causing vast changes to the environment. Research can help us understand those changes, how people respond to them, and how to reduce the negative impacts on natural ecosystems. Because environmental change has occurred relatively rapidly in the Copper River, the Copper River offers a unique opportunity to explore the relation of change to people’s lives and lifestyles and to learn more about the strategies they have developed to adapt to change.

The Copper River is an ideal place to study the relation between people and their environment for two reasons: (1) the area is such an outstanding place for natural science studies, and (2) there is a long history of human occupation, migration, and mingling.

Research would team natural scientists with specialists in cultural disciplines. Research opportunities include learning about:

- Early migration routes of people coming to North America from Asia
- Oral tradition and mythology to learn more about the early relation of people with their environment
- The effect of environment versus language on culture, values, perceptions, and identity
- The relation among environment and spirituality, cultural values, and economic systems
- The effects of human activities on the environment; for example, mining, construction of the railroad and road systems, and commercial fishing
- Human displacement as a result of depletion of natural resources

Science Commission Recommendations

The Copper River Science Commission supports increased research in the Copper River ecosystem. The great environmental diversity, relative ease of access, and variety of human-nature interactions make the area well suited to study environmental change and adaptation. Rapid ecological change, as opposed to the status quo, may have a positive effect on both primary biological productivity and evolutionary processes. Studying those processes may help us learn more about the effects of rapid change in modern society.

The major recommendations of the commission, aside from the many research opportunities listed elsewhere, are summarized here:

1. Delineate the Copper River research planning area broadly to include two major geographic areas, the upper Copper River basin and the Copper River Delta, connected by a third, the Copper River canyon. These environments are ecologically inseparable, experience many different environmental change agents, and include a diversity of people, wildlife, and fish. Glaciers, coastal tides, winds and currents, and human activities such as fishing, mining, and timber harvest have repeatedly shaped the biota and landforms of the area.

2. Facilitation of science and research should be considered a major goal of Federal land management agencies (Forest Service and National Park Service) in the Copper River ecosystem. New information is essential for all management activities and will contribute immeasurably to public education efforts—interpretive programs and environmental education.

3. Provide logistical support for research, including housing, transportation, computers, wetlabs, and other services or equipment needed by scientists.

4. Coordinate the activities of local agencies so they operate as a united support mechanism for research.

5. Establish a technical committee to advise on management decisions affecting research. The committee should be composed of local, national, and international members and should include various disciplines.

6. Promote and develop ties with scientists in other countries that have similar ecosystems, including Canada, the former Soviet Union, and South American countries such as Chile and Argentina. Sister-site relations should be explored.

7. Prepare improved, detailed geologic-vegetation maps for the entire Copper River ecosystem.

8. Establish meteorological and hydrological measurement protocols and stations throughout the ecosystem.

9. Create sampling schemes to estimate sediment and carbon budgets.

10. Develop liaisons with international agencies that have a global focus, including such institutions as Ecotrust, Conservation International, the Man and the Biosphere Program, and universities with international research initiatives.

11. The Forest Service should sponsor an interdisciplinary workshop to convey information about the opportunities for research, develop specific research proposals, supplement existing knowledge, and provide educational opportunities.

12. Develop a formal public outreach and education program to inform a wider public about research underway and new findings. Such a program should be directed by international as well as local audiences and should emphasize the interdisciplinary nature of the work.

13. Develop mechanisms to assess the effectiveness and relevance of current research programs. Evaluations should be made periodically to ensure that plans remain effective as changes occur to the ecosystem and to human values.

Knowledge as a Management Goal

Increasing knowledge is essential as a major goal of management policies. Although congressional directives require sustainable resource production, ecosystems are always changing because of natural processes and human activities. Human values also change, which leads to changes in management goals. Consequently, resource management policies must be flexible and reevaluated regularly. Management strategies also allow for adaptability.

Management plans must recognize the need for, and be based on, long-term research and monitoring. Plans also must support ongoing research, integrate results into management policies, and develop an infrastructure that protects research and monitoring activities and sites.

A strong science educational commitment is essential as a section in research and development plans with a strong and formal emphasis on translating scientific research results to society. This can be achieved in several complementary ways. Researchers could produce project reports that are oriented toward nonspecialists. The Prince William Sound Community College and other institutions could act as liaisons with local, regional, national, and international media to spread information about research in the Copper River ecosystem. Researchers could present public lectures about their hypotheses, research methods, and findings. Through these and other methods, science in the Copper River ecosystem will enable the general public to become more informed about change and adaptability and about environmental processes on a more global scale.

Finally, management plans could adopt a “systems” approach, recognizing that all parts of the ecosystem are integrally related to each other. Thus, research would be interdisciplinary and include various natural and cultural disciplines. Individual research projects should reflect this interdisciplinary thrust. Also, the impact of proposed research or management activities would be evaluated in the context of all other activities affecting the ecosystem. Policies, such as enhancement actions that are oriented toward one part of the system, must be assessed in this larger context. This direction can be demonstrated in several examples. For instance, moose research should be broadened beyond habitat preference and enhancement studies to include the energy basis for moose production, the effects of moose on other ecosystem components including humans, and the various effects of other ecosystem components such as humans and beavers on moose. Similarly, migratory bird research should include the energy basis for bird production, the effects of humans including researchers on birds, and adaptability of bird populations to environmental change.

Evaluating the Success of Research Management

It is important to regularly evaluate whether the plans are successful. These evaluations should ensure that plans remain effective as changes occur to the ecosystem and to human values. Many indicators will measure how well such plans function:

- The number and range of people, including scientists from a range of disciplines and nonspecialists, who want to be involved in research
- The productivity of research with research activities including both breadth and depth
- The impact that research has on management policies
- The effectiveness with which research results are made available to a nonspecialized general public
- The extent to which research programs are well balanced over time, represent diverse disciplines and examine several hypotheses

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Appendix: History of the Copper River Delta Institute

The Copper River Delta Institute was established in 1989 by the Pacific Northwest Research Station and Alaska Region of the USDA Forest Service as a consortium of national, state, and local governments, and other organizations interested in the future of the Copper River Delta. Their mission was to improve understanding, use, and management of natural resources through research, development, education, and interpretation.

Over time, the objectives of the institute were transformed by budget realities and changing expectations. Both were unplanned consequences of the science efforts to support the Tongass land management plan.

The major objectives of the institute were to:

- Provide a forum for interagency identification and prioritization of research, develop-ment, and management needs for the Copper River Delta.
- Attract funding for research and development activities needed to provide information for management purposes.
- Conduct inhouse and cooperative research, development, interpretation, and education activities on the resources of the Copper River Delta and the natural and human events that shape the ecosystem.
- Develop partnerships and cooperative agreements to obtain funding and for carrying out high-priority research, development, interpretation, and educational activities.
- Provide housing, transportation, office and laboratory space, and other services to scientists working on the delta.
- Maintain a data bank of information about the delta, administrative studies, and research projects, along with a bibliography of publications based on research conducted there.
- Serve as a source of information about the Copper River Delta for the local community.

For additional information, write to:

Acting Director
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Link to map

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