AN OVERVIEW OF ALASKA'S NATURAL ASSETS

PREPARED FOR

Alaska Conservation Alliance

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I. Introduction

The environment and natural resources of Alaska are our greatest assets. The natural environment is a store of value that provides us with life-sustaining services like breathable air and drinkable water. We rely on nature for resources such as oil, timber, and minerals. We value nature for hunting, fishing, subsistence, recreation, tourism, as well as cultural benefits. In order to make choices about how to use and to conserve our natural assets we must assess how much of these natural assets are available and why they are valuable.

This report is a broad overview of the abundance, status, and value of Alaska's primary natural assets. These assets include all aspects of nature that provide some benefits, services, income, or value. Table 1 lists the major categories of benefits from nature.[1] These benefits include *life support services* such as water storage, regulation of the chemical composition of the atmosphere, and cycling nutrients through the food chain. The natural environment provides valuable *raw materials* such as oil, trees, and minerals that we make into products. We also rely on nature for fish, crops, livestock, and wild animals that we consume as food.

Nature is also a valuable resource for *non-consumptive use*. For example, we enjoy outdoor recreation such as camping, hiking, picnicking, viewing wildlife, and skiing. These non-consumptive uses of nature enrich our lives and are the basis for much of the Alaska tourism industry. More broadly, some people value natural assets even if they never use or visit the assets. These "*non-use" or cultural values* include the value of leaving natural wonders as bequests to our children; the value of knowing natural assets are intact and alive; as well as historical, educational, and scientific values for nature.

In Part II of this report we identify and describe major components of our natural assets. Because this is an overview, we take a broad look at many aspects of our natural assets and pass quickly across a lot of detail. For more detailed information, we provide links to web sites and suggestions for other reading at the end of each section. In Part III of this report, we look more closely at why these assets are valuable and present methods to estimate the monetary value of selected natural assets.

Table 1: Benefits from Nature	
Watershed Benefits	Erosion control and sediment retention Local flood reduction Influence on stream flows Water regulation Water supply storage and retention
Ecological Processes	Fixing and cycling of nutrients Soil formation Circulation and cleansing of air and water Regulation of atmospheric chemical composition Pollination Climate regulation Disturbance regulation Global life support Waste treatment
Bio-Diversity	Gene resources Species protection and biological control Ecosystem diversity Evolutionary processes
Habitat	Habitat for resident and transient populations
Consumptive Benefits	Oil, gas, minerals, timber, and other marketable commodities Subsistence activities and harvests Sports hunting and fishing Agricultural crop and livestock products
Non-Consumptive Use	Outdoor recreation Tourism Wildlife viewing
Cultural Benefits	Aesthetic Spiritual Historical Preservation Existence Education & research Scientific knowledge
Future Values	Option value Bequest value

Source: Robert Costanza, Ralph d'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton, and Marjan Van den Belt, "*The Value of the World's Ecosystem Services and Natural Capital,"*, in *Nature,* Vol. 387, No. 15 (May 1997), p 254. In addition, J.A. Dixon and P.B. Sherman, "Economics of Protected Areas," Ambio, Vol. 20, no. 2, 1991, pp. 68-74.

II. Our Natural Assets

A. Life Support Services

The ecosystem provides life-support services that keep humans and all other life forms alive. Ecological, biological, and geological processes in the ecosystem as a whole provide these life-support services. Table 2 on the following page lists the major life-support services provided by nature.

We rely on the ecosystem to regulate the chemical composition of our atmosphere so we have air to breathe, to control the climate so that temperatures are habitable, and to regulate the circulation and filtration of water so we have water to drink. The ecosystem as a whole controls and limits the flow of water to dampen and to limit the destruction of disturbances such as storms and draughts. Nature retains and holds water supplies so that we have water available when we need it. It limits erosion and retains soils so they are available for cultivation and other uses.

The ecosystem both creates and limits the proliferation of life. It creates soil for forests and vegetation, cycling and extracting nutrients for food, and pollinating plants so they can reproduce. Nature limits animal populations through predation, provides habitat for animal populations, breaks-down and detoxifies wastes from humans and animals, and provides genetic resources for medicines, disease-resistant crops, horticultural plants, and pets.

It is beyond the scope of this report to describe the abundance and status of all these ecological processes in Alaska. Furthermore, many of these life-support services are provided by the global ecosystem as a whole, so it is not meaningful to separate the portion provided by the Alaska ecosystem alone.

For a comprehensive, detailed, and authoritative description of the abundance, status, and health of Alaska ecosystems see

- *EcoRegions of Alaska U.S. Geological Survey Professional Paper 1567*, by Alisa L. Gallant, Emily F. Binnian, James M. Omernik, and Mark B Shasby, U.S. Government Printing Office, Washington, D.C., 1995.

- This paper is available on the World Wide Web as *Ecoregions of Alaska - U.S. Geological Survey Professional Paper 1567* at http://edcwww.cr.usgs.gov/pecora/binnian/pp1567.htm.

- In addition, the Alaska Geospatial Clearinghouse has a comprehensive list of links to ecological, natural resource, and environmental data at http://agdc.usgs.gov/ .

Table 2: Life Support Services from Nature
Gas regulation Regulation of atmospheric chemical composition. Example: CO_2/O_2 balance, O_3 for UVB protection, and SOx levels
Climate regulation Regulation of global temperature, precipitation, and other biologically mediated climactic processes at global or local levels. Example: Greenhouse gas regulation
Disturbance regulation Capacitance and damping of ecosystem response to environmental fluctuations. Example: Storm protection, flood control, drought recovery, and other aspects of habitat response to environmental variability.
Water regulation Regulation of hydrological flows and circulation on land, air, and subsurface. Example: Provisioning of water for agriculture, industrial processes, and transportation
Water supply Storage and retention of water. Example: Provisioning of water by watersheds, reservoirs, and aquifers
Erosion control and sediment retention Retention of soil within an ecosystem. Example: Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands
Soil formation Creation of soil for farming, plants, and sustaining habitat Example: Weathering of rock and the accumulated organic material

Table 2: Continued: Life Support Services from Nature
Nutrient cycling Storage, internal cycling, processing, and acquisition of nutrients. Example: Nitrogen fixation and other elemental or nutrient cycles
Pollination Movement of floral gametes. Example: Provisioning of pollinators for the reproduction of plant populations
Biological control Regulation of animal populations through predation. Example: Predator control of prey species, reduction of herbivores by top predators
Habitat Habitat for resident and transient populations. Example: Nurseries, habitat for migratory species, regional habitats for locally harvested species, or over-wintering grounds
Waste treatment Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and Compounds. Example: Waste treatment, pollution control, detoxification
Genetic Resources Sources of unique biological materials and products. Example: Medicine, products of materials science, genes for resistance to plant pathogens and crop pests, ornamental species such as pets and horticultural plants.
Source: Costanza et al. 1997.

B. Energy and Minerals

1. Oil and Natural Gas

The world economy is critically dependent on oil as a source of energy. As consumers, we depend on oil as a raw material for making gasoline for automobiles, fuel for industries, and plastic and synthetic materials for millions of products. The Alaska economy and state government rely on the sale of oil as a critical source of income. The oil industry generates about half of the total output of the Alaskan economy, is the driving force behind about a quarter of all jobs in the state, and provides more than half of the revenues for the Alaska state government.[2]

Natural gas is often extracted along with oil and is also a valuable source of energy. Natural gas from the North Slope is the primary source of energy for much of the nearby petroleum extraction operations and the first two pump stations of the Trans Alaska Pipeline. Much of the natural gas extracted from the North Slope has been re-injected into the ground to help remove additional oil. The re-injected natural gas could be extracted later when it is economically feasible to move it to markets. Natural gas extracted from Cook Inlet provides the energy for nearly all of the electric power generated for Anchorage.

We can measure the amount of oil and gas assets in Alaska by “proven reserves." Proven reserves include all oil and gas in the ground that has been discovered and can be extracted with available technology and at current world market prices. Table 3 summarizes total remaining proven reserves of oil and gas in Alaska and the cumulative amount of oil and gas extracted over time. This table reveals that we have depleted about 64% of our total proven reserves of oil and about 20% of our natural gas reserves.

Table 3: Remaining Proven Reserves of Oil and Gas in Alaska in 1998 (millions of barrels of oil and billions of cubic feet of natural gas)

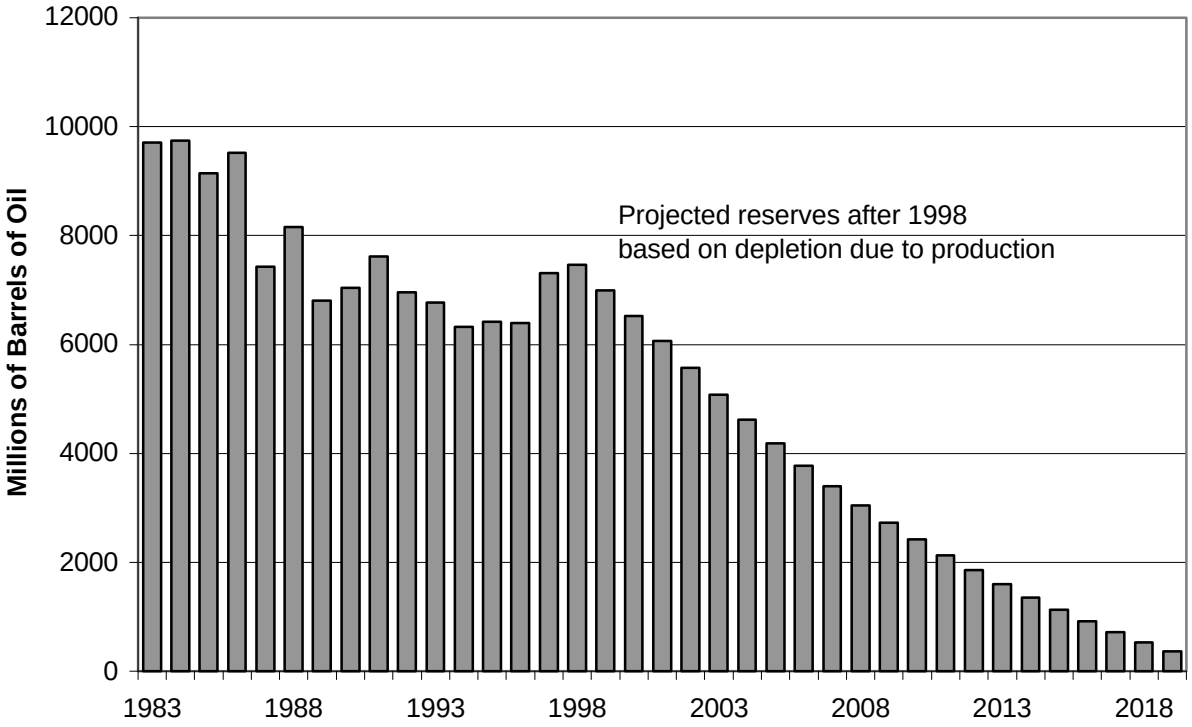
Region	Commodity	Cumulative Extraction	Remaining Reserves	Percent Depleted*
North Slope	Oil	11,803	7,385	62%
	Gas	3,289	31,156	10%
Cook Inlet	Oil	1,226	76	94%
	Gas	5,361	3,066	64%
State Total	Oil	13,029	7,461	64%
	Gas	8,650	34,222	20%

* Percent Depleted = Cumulative Extraction / (Cumulative Extraction + Remaining Reserves)

Source: Historical and Projected Oil and Gas Consumption, Alaska Department of Natural Resources, Oil and Gas Division, April 1998.

The amount of proven reserves changes over time due to oil extraction, discovery of new deposits, changes in prices, and availability of new technologies. As shown in Figure 1, the level of proven reserves has varied over the past fifteen years; but the general level of reserves has declined -- primarily due to oil extraction. If we continue to extract oil from the ground at projected rates, the Alaska Oil and Gas Commission estimates that we will deplete current proven oil reserves in Alaska in about 2020. They project that current proven oil reserves in Cook Inlet will be depleted in 2003.[3]

Figure 1: Projected Alaska Proven Oil Reserves



Source: ISER estimates and Alaska Oil and Gas Division, Historical and Projected Oil and Gas Consumption, April 1998.

If we discover new deposits of oil that we can extract with available technology and at prevailing market prices, then these projections would change. Currently, the state and federal governments are considering opening the National Petroleum Reserve - Alaska for exploration of oil. (Notably, the National Petroleum Reserve - Alaska is also valuable as wildlife habitat, wilderness, and recreational resource. We describe the value of habitat and wilderness in more detail in Sections II.C and II.D of this report). The most recent estimates of the mean amount of recoverable oil in the National Petroleum Reserve - Alaska ranges from 2.1 to 2.5 billion barrels.[4] If we were to add these deposits to our proven reserves, then our total proven reserves would increase by about thirty percent. At current rates of production, these additional reserves would be depleted in five to ten years.

The amount of proven reserves could also change with the advent of new technologies or changes in the price of oil. If the price of oil increases in the future due to increasing scarcity, some of our reserves that are currently not recoverable at existing prices would become part of our proven reserves. Conversely, if the world price of oil declines, then the amount of deposits that can be economically extracted would also decline and our proven reserves would be reduced. If new methods, technologies, or processes for extracting oil make it economically feasible to extract currently unrecoverable oil deposits, then we would add these deposits to our proven reserves.

For more detailed information about our oil and gas reserves and projected extraction, see

- *Historical and Projected Oil and Gas Consumption*, Division of Oil and Gas, Alaska Department of Natural Resources, May1998.

- This report and other oil and gas information are available online at http://www.dnr.state.ak.us/oil/data/data.htm.

2. Minerals and Industrial Materials

Minerals such as coal, gold, silver, platinum, copper, tin, and lead are valuable commodities sold in the world market for energy and use in manufacturing products. The mining industry extracts these and other minerals from mines throughout Alaska. The Red-Dog mine in northwestern Alaska is extracting the largest zinc deposits in the world. The Usibelli Coal mine in interior Alaska extracts coal for use as energy in Fairbanks and in South Korea. Mines in Southeast and Interior Alaska continue to extract gold. Sand and gravel for construction use is mined in most areas of the state. Table 4 lists the cumulative amount of each type of mineral and industrial material extracted over time and estimates of the remaining proven reserves of these geological assets.

For more information about mineral mining, see

- *Alaska's Mineral Industry*, 1995, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Special Report 50, by T.K. Bundtzen, R.C. Swainbank, A.H. Clough, M.W. Henning, and K.M. Charlie.

- The U.S. Department of Geological Survey provides comprehensive results from surveys of mineral resources in Alaska at http://www-mrs-ak.wr.usgs.gov:80/wrmrsAK/.

Table 4: Cumulative Extraction and Proven Reserves of Minerals and Industrial Materials in Alaska in 1998

Mineral	Units	Cumulative Extraction	Proven Reserves
Gold	ounces	30,250,336	Not available
Sand and Gravel	tons	709,880,000	Not available
Copper	pounds	1,380,000,000	Not available
Coal	million tons	29	1834.5
Platinum	ounces	575,000	350000
Silver	ounces	20,084,510	Not available
Uranium	pounds U3O8	2,400,000	Not available
Tin	pounds	4,800,000	125,973,000
Lead	pounds	50,056,000	Not available
Marble-limestone	tons	2,300,000	Not available
Barite	tons	850,000	Not available
Antimony	pounds	10,493,360	10,500,000
Mercury	pounds	3,160,000	Not available
Gypsum	tons	505,000	Not available
Tungsten	pounds of WO3	286,000	Not available
Chrome	tons	36,849	300,000
Asbestos	pounds	94,000	55 million tons
Graphite	pounds	540,000	Not available
Cobalt	million tons	0	9
Fluorine	million tons	0	4.94
Nickel	billion pounds	0	1.123

Sources:
Alaska's Mineral Industry, 1995, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Special Report 50, by T.K. Bundtzen, R.C. Swainbank, A.H. Clough, M.W. Henning, and K.M. Charlie,

Review of Alaska's Mineral Resources, Division of Geological and Geophysical Surveys, Department of Natural Resources, 1982 by T.K. Bundtzen, G.R. Eakins, and C.N. Conwell,

Alaska's High Rank Coals, Information Circular 33, Division of Geological and Geophysical Surveys, Department of Natural Resources, August 1990

C. Forests and Plants

Forests and plants provide life–support services such as the regulation of the chemical composition of the atmosphere, extracting nutrients from the soil, transformation of soil into forage, and reducing erosion by retaining soil. Forests and vegetation provide habitat for animals as well as recreational opportunities for Alaskan residents and tourists. Many people also value forests and vegetation for their aesthetic beauty, scientific and educational value, as well as the value of preserving intact, living ecosystems.

As consumers, we depend on trees as valuable raw materials for producing lumber, paper, and other products made from wood and pulp. Many communities in Southeast Alaska rely on logging and timber processing as sources of income and employment. Residents of these communities value logging as a lifestyle that they have inherited from previous generations. Trees and plants also are harvested for other consumptive uses: harvested trees are burned for heat, subsistence users harvest certain plants for food or for other products; and farmers cultivate domesticated crops for food.

1. Forests

The forests of Alaska can be roughly divided into two broad areas – 1) the coastal forest found in Southeast Alaska and along the coasts of Southcentral Alaska and 2) the boreal forests covering much of interior Alaska. The coastal forests comprise a total of 13.7 million acres. As shown in Figure 2 on the next page, these coastal forests are composed predominantly of marine and western hemlock and Sitka Spruce along with western red cedar, paper birch, white spruce, and poplars. The interior forests of Alaska cover about 115.4 million acres and range roughly from the latitude of the Chugach Mountains north to the Brooks Range where the tree line ends. As shown in Figure 3, these interior forests are composed of white spruce, paper birch, and poplar.[5]

The abundance of our forest assets is constantly changing over time due to growth, mortality, and timber harvest. Table 5 summarizes these changes over the past several years. Interior forests experience about 5,003 cubic feet of annual growth per acre. Coastal forests grow at the rate of about 10,064 cubic feet per acre per year. Wildfires, insects, and diseases kill many acres of forest each year. Both interior and coastal forests are threatened by wildfires, but most of the wildfires occur in interior forests. Over the past decade, Alaskan forests have experienced from 260 to over 900 wildfires a year and as much as 3 million acres have been burned since 1990. The spruce bark beetle is the primary insect threatening Alaska forests. In 1985, almost 300,000 acres of Alaskan forest had active spruce beetle infestations, and the beetle had spread to over one million acres of active beetle activity in 1996. The total number of acres with active infestation declined by 50% in 1997 to 563,741 acres. Not included in these counts are over 2.3 million acres of spruce stands that are almost entirely dead and have little or no remaining host material to support further beetle activity.[6]

Figure 2: Composition of Coastal Forests in Alaska

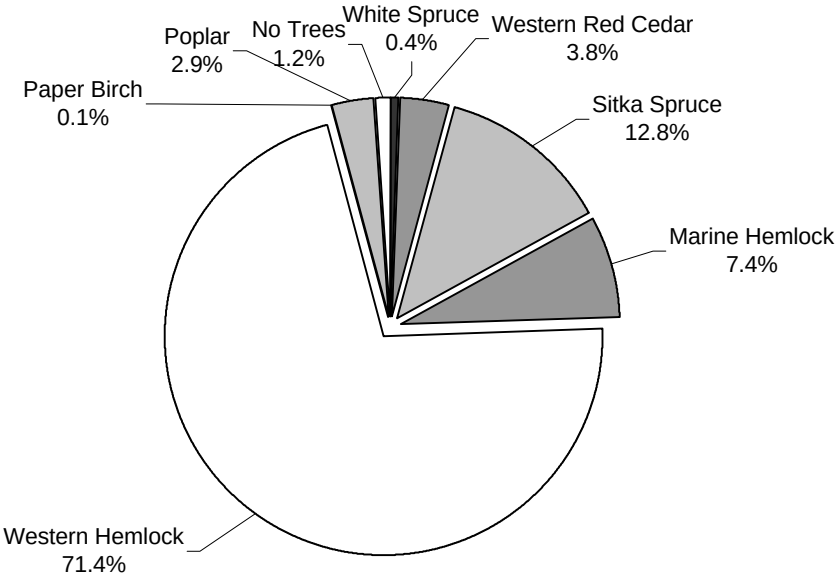
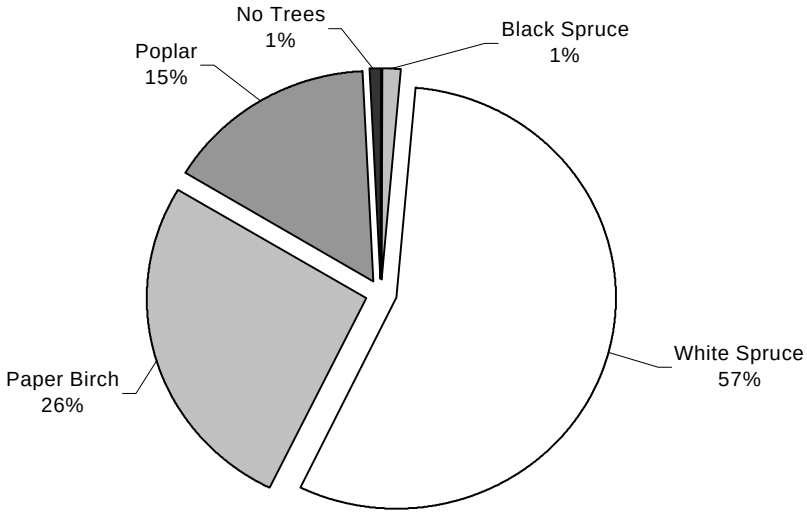


Figure 3: Composition of Interior Forests in Alaska



Source: University of Alaska Cooperative Extension Service, *Alaska's Unreserved Productive Forest Lands,* Alaska Natural Resource Management Series, based on information from U.S. Forest Service Anchorage Forestry Sciences Laboratory resource bulletins, September 1995.

Table 5: Summary of Additions and Reductions to Alaska Forests

Additions: Annual Growth[1]

Coastal Forests	
cubic feet per acre	---------10,064 average annual growth each year--------
millions of cubic feet	------1,161,386 average annual growth each year ------
Boreal Forests	
cubic feet per acre	---------5,003 average annual growth each year---------
millions of cubic feet	---------68,541 average annual growth each year--------

Reductions

	1992	1993	1994	1995	1996	1997
Insect Damage (acres damaged)[2]						
Spruce Beetle Damage	604,800	724,800	639,900	892,800	1,130,800	563,700
Damage by other Insects	491,900	435,900	482,000	458,200	932,900	657,700
Disease Damage (acres damaged) [2]						
Yellow-cedar decline	NA	NA	NA	578,480	474,864	477,540
Other disease damage	NA	NA	NA	10,002	8,891	34,977
Other forms of Damage (acres damaged) [2]						
Porcupine damage	NA	NA	NA	375	633	1,163
Blown down / wind throw	NA	NA	NA	49	618	2,225
Water damage	NA	NA	NA	4,775	5,635	2,049
Winter damage	NA	NA	NA	NA	NA	2,948
Landslide damage	NA	NA	NA	465	498	4,449
Wildfires[3]						
Number of Fires	474	869	643	421	NA	NA
Acres Burned	150,057	713,116	265,722	43,945	NA	NA
Timber Harvest[4]						
Million Board Feet Harvested	1,066,336	927,474	896,325	803,804	685,155	NA

NA indicates data is not available from published sources.

Sources:

[1] University of Alaska Cooperative Extension Service, *Alaska's Unreserved Productive Forest Lands*, Alaska Natural Resource Management Series, based on information from U.S. Forest Service Anchorage Forestry Sciences Laboratory resource bulletins, September 1995.

[2] Kathleen Matthews, Dustin Wittwer, Ken Zogas, Ed Holsten, Lori Trummer, Beth Shultz, Paul Hennon, Mark Shultz, Roger Burnside, Michele Gorham, *Forest Insect and Disease Conditions in Alaska -- 1997,* General Technical Report R10-TP-70, Forest Health Protection, State and Private Forestry Alaska Region, USDA Forest Service, and Division of Forestry Resources, Alaska Department of Natural Resources, December 1997.

[3] The Alaska Division of Forestry, Wildfire Monitoring and Reporting Program at http://www.dnr.state.ak.us/forestry/fire_faq.htm

[4] Alexandra Hill and Teresa Hull*, Timber Harvest and Wood Products Manufacture in Alaska*, 1996, prepared for USDA Forest Service, Pacific Northwest Experiment Station, Forestry Services Laboratory, ISER report, September 1997.

Table 6 shows the amount of land in Alaska with commercial timber. The U.S. Forest Service classifies forest land as "productive unreserved," "productive reserved," or "other forest land." Land classified as productive unreserved forestland has commercial timber and does not have logging restrictions. Productive reserved forestland includes parks, refuges, wilderness areas, or other land with restrictions on logging. "Other" forestland includes forested areas in urban areas or in areas with few or sparse trees.[7]

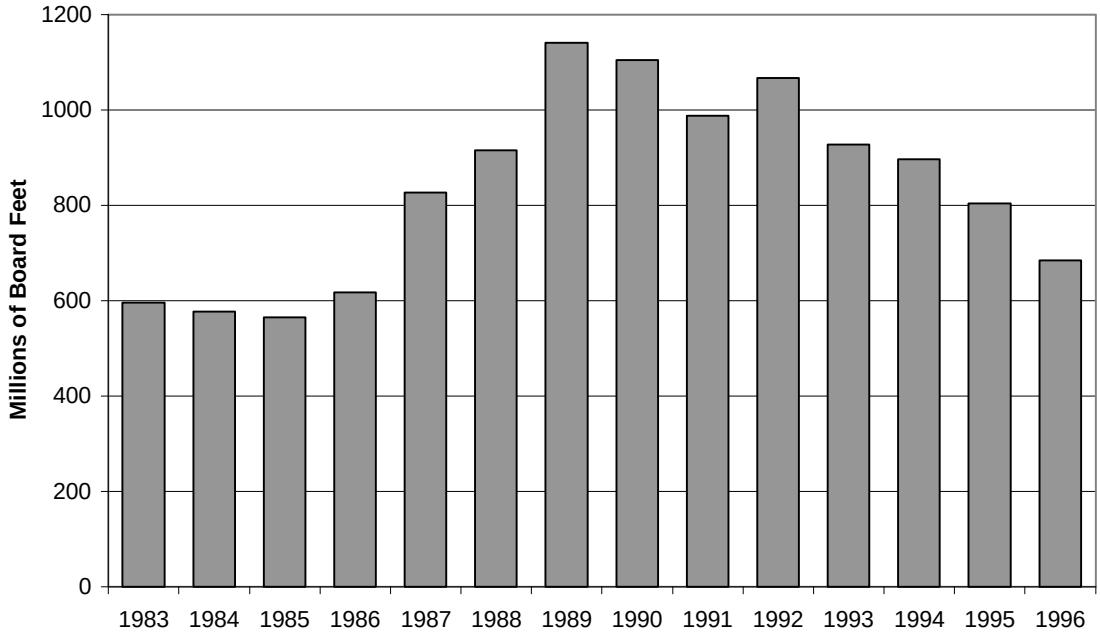
As shown in Figure 4, about 600 to 1100 million board feet of timber are harvested annually from public and private lands combined in Alaska.[8] There are currently no regularly published estimates of the total amount of acreage used for logging throughout Alaska. These estimates would be useful to help policy makers decide how much of our forests should be harvested and how much should be left intact.

Table 6: Productive Forest Land Area in Alaska
by Land Classification and Region
(Millions of Acres)

Region	Total Land Area	Total Forest Land	Components of Total Forest Land			Other Non-Forest Land
			Productive Unreserved Forest Land	Productive Reserved Forest Land	Other Forest Land	
Interior	329.1	115.4	10.1	3.4	101.9	213.7
Coastal	35.6	13.7	5	2.6	6.1	21.9
Total for State	364.7	129.1	15.1	6	108	235.6

Source: University of Alaska Cooperative Extension Service, *Alaska's Unreserved Productive Forest Lands*, Alaska Natural Resource Management Series, based on information from U.S. Forest Service Anchorage Forestry Sciences Laboratory resource bulletins, September 1995.

Figure 4: Timber Harvest on Private and Public Lands in Alaska



Source: Alexandra Hill and Teresa Hull, Timber Harvest and Wood Products Manufacture in Alaska, 1996, prepared for USDA Forest Service, Pacific Northwest Experiment Station, Forestry Services Laboratory, ISER report, September 1997.

2. Other Plants

Brush, vegetation, and plants other than forests are valuable as subsistence food, agricultural crops, habitat for animals, and recreational resources. Roughly, 30,000 acres of land were dedicated last year to crop production in Alaska. Farmers harvested oats, barley, hay, potatoes, cabbage, lettuce, carrots, and other vegetables for food. Each year, rural subsistence users harvested about 850,000 pounds of plants for subsistence use during the 1990's.[9]

As listed in Table 7 below, each region of Alaska exhibits different types of vegetation. Southeast Alaska is covered predominantly with western hemlock and Sitka spruce forests (68%). The remainder of the vegetation in Southeast Alaska is alpine tundra or barren ground in mountains (31%). Alpine tundra or barren ground (mostly in the Chugach and Talkeetna Mountains) covers nearly half of Southcentral Alaska (46%). The remainder of land area in Southcentral Alaska is coastal western hemlock forest (15%), spruce forests, and various forms of brush and tundra.[10]

The interior regions of the state surrounding the Yukon River and Yukon Flats are dominated by spruce and hardwood forests in lower elevations. Alpine tundra and barren ground are the prevalent ground cover in the Alaska and Brooks mountain ranges. Both Northwestern

Alaska around the Seward Peninsula and Southwestern Alaska along the Aleutian Peninsula are covered mostly by moist, wet, and alpine tundra and interspersed with hardwood and spruce forests. The Arctic region north of the Brooks Range is dominated by moist, wet, and alpine tundra along with some high brush.

Table 7: Distribution of Vegetation in Alaska

Region	Forests				Brush		Tundra			Total Land Area
	Coastal Western Hemlock & Sitka Spruce Forest	Bottom land Spruce & Poplar Forest	Upland Spruce & Hard-wood Forest	Lowland Spruce & Hard-wood Forest	High Brush	Low Brush, Muskeg, & Bog	Moist Tundra	Wet Tundra	Alpine Tundra and Barren Ground	
Southcentral										
Millions of Acres	5.9	1.1	4	4.3	4	0.6	3.6	1	20.9	45.4
Percent of Region	13%	2%	9%	9%	9%	1%	8%	2%	46%	100%
Arctic										
Millions of Acres			0.3		6.3		26.5	8.5	7.3	48.9
Percent of Region			1%		13%		54%	17%	15%	100%
Northwest										
Millions of Acres		1.4	6.6	1	4	0.1	12.3	7	9.7	42.1
Percent of Region		3%	16%	2%	10%	0%	29%	17%	23%	100%
Southwest										
Millions of Acres		3.5	9.3	6.6	2.6	0.5	16.8	9.2	18.7	67.2
Percent of Region		5%	14%	10%	4%	1%	25%	14%	28%	100%
Yukon										
Millions of Acres		12	43.4	23.2	0.7	9.2	7	6.6	21.1	123.2
Percent of Region		10%	35%	19%	1%	7%	6%	5%	17%	100%
Southeast										
Millions of Acres	16.6							0.3	7.5	24.4
Percent of Region	68%							1%	31%	100%
State Total										
Millions of Acres	22.5	18	64.6	35.1	17.6	10.4	65.5	32.6	84.9	351.2
Percent of Region	6%	5%	18%	10%	5%	3%	19%	9%	24%	100%

Source: Lidia Selkreg et al., *Alaska Regional Profiles*, Alaska Environmental Information and Data Center, University of Alaska, 1976.

For more information about forests and vegetation in Alaska, see

- The U.S. Department of Geological Surveys and Alaska Department of Natural Resources Division of Forestry maintain a Forestry Health Monitoring Clearinghouse with extensive information about fire, insect, and timber harvests in Alaska at http://agdc.usgs.gov/data/projects/fhm/.

- U.S. Forest Service maintains a Forest Health Protection, State and Private Forestry, Alaska Region web site at http://www.fs.fed.us/r10/spf/fhpr10.htm. This site has information about insect and fire damage to Alaska forests.

- The Alaska Department of Natural Resource, Division of Forestry provides detailed information about disease and insect threats to Alaska's forests at http://www.dnr.state.ak.us/forestry/web_bugs.htm.

- The Alaska Department of Natural Resources, Division of Forestry also has a separate Wildfire Monitoring and Reporting Program at http://www.dnr.state.ak.us/forestry/fire_faq.htm.

- University of Alaska Cooperative Extension Service, University of Alaska Fairbanks, *Alaska's Unreserved Productive Forest Lands*, September 1995.

- F*orest Resources of the United States, 1992*, Douglas Powell, Joanne Faulkner, David Darr, Zhiliang Zhu, Douglas MacCleery, Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, 1992.

- U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, Forest Service *Timber Resource Statistics* for various Alaska inventory units.

- Leslie A. Viereck, Elbert L. Little, *Alaska's Trees and Shrubs*, Agriculture Handbook No. 410, Forest Service, U.S. Department of Agriculture, Washington D.C., 1972.

- Verna Pratt, *Field Guide to Alaskan Wildflowers*, Alaskacrafts Publishing, Anchorage, 1989.

- Alaska Agricultural Statistics Service, U.S. Department of Agriculture, *Alaska Agricultural Statistics 1997*.

D. Animals

Sports hunters and subsistence users harvest wild animals for food, furs, and other uses. Livestock farmers and herders raise domesticated animals for food and other commodities. Besides being consumed as food or products, people also rely on domesticated animals to help with work: dogs pull sleds and ski-jorers while horses pull carriages and plows. Domesticated dogs, cats, birds, and other animals provide companionship and enjoyment to pet owners.

Both tourists and residents value the opportunity to view live wild animals in their natural habitat. Some people value preserving wild animals so they can remain alive and undisturbed. They may value preserving the animal's habitat, preserving animals in general, or preserving a particular rare or endangered species. Wild animals are also an integral part of the ecosystem: they provide food for other animals, population control through predation, distribution and cycling of nutrients, pollination of plants, distribution of genetic material, biodiversity, and other contributions to life-support services of the ecosystem.

1. Terrestrial Mammals

Sports hunters hunt deer, moose, caribou, and other large land mammals for food and trophies. Subsistence users harvest large mammals such as moose, caribou, and other mammals for food, furs, or other products. Large land animals, such as bear, caribou, moose, and wolves, are popular among tourists and residents for wildlife viewing. Large land mammals area also valuable to many people who value knowing that these wild animals are alive and preserved in their natural habitat.[11]

Table 8 lists the most recent published information about the abundance and status of land mammals in Alaska. More detailed information about the health and status of land mammals is available for specific herds in many specific areas (called game management units).[12] However, there is only limited information about the population and status of these land mammals statewide.

The primary factors affecting the population of these animals includes the environmental health of their habitat, weather conditions, predators, death by other natural causes, and hunting. The number of animals killed by sports hunters on average each year over the past five years are also listed in Table 8. Each year sportshunters take about 50,000 animals -- mostly black tail deer, caribou, and moose. Rural subsistence users harvest about 8,740,000 pounds of terrestrial animals annually and urban subsistence users take about 2,940,000 pounds annually. Besides the harvest of wild animals, about 15,000 animals are also raised as domesticated livestock in Alaska and about 80% were slaughtered for consumption as food.[13]

Trappers and hunters also take small land mammals including Arctic fox, beaver, coyote, lynx, marten, mink, and wolverine for their furs. There is currently no statewide information about the populations of these species, but the number of these animals killed for their furs each year are listed in Table 8.[14] Numerous other small mammals including everything from bats, hares, lemmings, pikas, porcupines, shrews, and voles also populate the state. There are a

variety of special studies of many individual species in selected areas, but there is little comprehensive statewide information available for these species.

- For more information about the behavior, range, habitat, and food of terrestrial mammals see The Alaska Department of Fish and Game Wildlife Notebook Series, available online at http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm.

- For information about sports hunting harvests, see Enid Keyes, Rebecca Stauch, Suzan Bowen, *Alaska Wildlife Harvest Summaries, 1994 - 1995,* Alaska Department of Fish and Game, March 1996.

2. Marine Mammals

Subsistence hunters harvest walrus, seals, and whales for food and other uses. Annual subsistence harvest of marine mammals totals 6,118,000 pounds of all types of marine mammals each year.[15] Tourists and residents also value marine mammals for their wildlife viewing opportunities and their existence as wild animals in their natural habitat.[16]

Table 9 lists published estimates of the population of marine mammal species in Alaska. The Stellar sea lion is of particular concern since it is near the top of the food chain and has experienced precipitous drop in population from 180,000 in 1960 to less than 50,000 in 1994. Similar declines in population have occurred in Russia and Pacific Northwest from British Columbia to California. The National Marine Mammal Laboratory Alaska Ecosystem Project is currently studying the sea lion population decline and the connection with groundfish fisheries in the Bering Sea and Aleutians.[17]

For more detailed information about marine mammals,

- Alaska Department of Fish and Game has more detailed information about the behavior, range, and habitat of marine mammals in Alaska in its Wildlife Notebook page at http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm,

- The U.S. Fish and Wildlife Marine Mammals program provides detailed information about the population, behavior, habitat, and status of sea otters, Pacific Walrus, and Polar Bears at http://www.r7.fws.gov/mmm/mmmhome.html.

- U.S. Department of Commerce, Alaska Ecosystems Page discusses Stellar Sea Lions in more detail at http://nmml.afsc.noaa.gov/akprog.htm. For information about the decline in sea lions, refer to http://nmml.afsc.noaa.gov/sslhome/decline.htm.

Table 8: Summary of Published Data on Terrestrial Mammal Populations in Alaska

Large Mammals Hunted by Sports Hunters for Food and Trophies

Animal	Estimated Population in 1995[1]	Average Annual Number of Animals Harvested 1991-1994[2]
Caribou	Hundreds of Thousands	13,644
Dall Sheep	60,000 to 80,000	1,188
Elk	1,250 to 1,550	85
Mountain Goat	20,000 to 25,000	487
Moose	144,000 to 166,000	6,765
Black Tail Deer	350,000 to 400,000	23,121
Musk Ox	2,500	91
Bison	870	107
Brown Bears	25,000 to 39,000	1,165
Black Bears	100,000 to 200,000	1,707
Wolves	7,532 to 10,008	1,287

Small Mammals Trapped and Hunted for Furs

Animal	Estimated Population in 1995[1]	Average Annual Number of Animals Harvested 1991-1994[2]
Arctic Fox	Furbearer	515
Beaver	populations are	5,199
Coyote	not available	59
Lynx		1,350
Marten		4,748
Mink		1,189
Wolverine		531

Sources:
[1]Alaska Department of Fish and Game, Wildlife Conservation Division, summary statistics on terrestrial mammal populations assembled from "Federal Aid in Wildlife Restoration Annual Performance Reports Survey-Inventory Activities," 1995, and provided by Mary Hicks, telephone conversation, October 22, 1998.

[2]Enid Keyes, Rebecca Stauch, Suzan Bowen, *Alaska Wildlife Harvest Summaries, 1994 - 1995,* Alaska Department of Fish and Game, March 1996.

Table 8 continued: Summary of Published Data on Terrestrial Mammal Populations in Alaska

Terrestrial Animals Harvested by Subsistence Users During the 1990's[3]

Type of User	Average pounds of terrestrial animals harvested annually
Rural subsistence users	8,740,000 pounds
Urban subsistence users	2,940,000 pounds

Farm Livestock Raised for Food and other Agricultural Products in 1996[4]

Animal	Commodity	Number of Animals on Farms	Pounds of Commodity Produced
Beef Cows	Beef	9,800	1,165,000
Milk Cows	Milk	900	13,500
Hogs and Pigs	Pork	1,600	666,000
Sheep Meat	Mutton	1,700	20,000
Sheep Wool	Wool	1,700	7,000
Reindeer	Meat	Not available	205,000

Sources:

[3]Robert Wolfe, *Subsistence Food Harvests in Rural Alaska, and Food Safety Issues,* paper presented to the Institute of Medicine, National Academy of Sciences Committee on Environmental Justice, Spokane Washington.

[4]Alaska Agricultural Statistics Service, U.S. Department of Agriculture, *Alaska Agricultural Statistics 1997.*

Table 9: Summary of Published Data on Marine Mammal Populations in Alaska

Marine Mammal	Alaska Habitat Management Guides[1]	Alaska Environmental Information Data Center[2]	U.S. Department of Fish and Wildlife Marine Mammals Management Program[3]	Notes and Comments
Beluka Whale	25,000			
Bowhead Whale	4,400			
Orca		Thousands		
Gray Whale				Small numbers, 17,000 worldwide
Humpback				750 to 1286 in North Pacific
Blue Whale				no data available
Polar Bears	5,700 or more in 1970's		3,000 to 5,000	Stable
Sea Otter		100,000 to 160,000	100,000 minimum	Currently increasing. Hunted to near extinction from 1742-1911
Pacific Walrus	270,000 to 280,000		188,316 minimum	Stable or slight decline.
Steller Sea Lion		242,000	Less than 50,000	245,000 to 290,000 worldwide
Harbor Seal		200,000		320,000 in North Pacific
Ringed Seal	1 to 1.5 million			
Northern Fur Seal	1.25 million			1.8 million worldwide, harvested down to 300,000 from 1786-1911
Ribbon Seal				no data available
Spotted Seal				no data available
Bearded Seal				no data available

Sources:
[1] Alaska Department of Fish and Game, Alaska Habitat Management Guides, Southcentral, Southwest, Southeast, Western, and Interior Regions: Distribution, Abundance, and Human Use of Fish and Wildlife, 1985,

[2] Alaska Environmental Information and Data Center, "Wildlife Populations of Prince William Sound: A Synthesis of the Open Literature," June 1990.

[3] U.S. Fish and Wildlife Service, Marine Mammal Management minimum population estimates from web page at http://www.r7.fws.gov/mmm/mmmhome.html. Stellar Sea Lion Populations from U.S. Department of Commerce, National Marine Mammal Laboratory, Alaska Ecosystem Project, at http://nmml.afsc.noaa.gov/akprog.htm.

3. Birds

Birds are a valuable part of the ecosystem; they are valued for wildlife viewing; they are harvested for food; and many people value their existence as living birds in the wild. Alaska is home to over 445 species of birds. Most of these species are migratory birds but some of the birds stay in Alaska all year. Most migrate to Canada, Central America, South America, Asia, or the lower 48 United States. Populations of selected birds in Alaska are listed in Table 10 on the next page. Table 11 summarizes the significance of birds in Alaska based on information provided by the U.S. Fish and Wildlife Service Migratory Bird Program.

For more information about birds in Alaska

- The U.S. Fish and Wildlife Service Migratory Bird Program provides detailed information about shorebirds, seabirds, raptors, landbirds, and waterfowl in Alaska at its web site at http://www.r7.fws.gov/mbm/mbmpg1.html.

- Alaska Department of Fish and Game Wildlife Notebook Series provides detailed information about select bird species and is available at http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm.

- The National Audubon Society provides information about Alaska birds at http://www.audubon,org/bird/watch/.

- Robert Armstrong, *Guide to Birds of Alaska,* Alaska Northwest Books, Anchorage, Seattle, 1990.

Table 10: Abundance of Selected Birds in Alaska

Bird	Alaska Habitat Management Guide, 1985[1]	Alaska Environmental Information and Data Center, 1990[2]
Yellow Billed Loon		3,500 to 5,000
Northern Fulmar	1.5 million	1.5 to 2 million
Sooty Shearwater	8 million	Several million
Short Tail Shearwater	16 million	Several million
Fork-tailed Storm Petrel	5 million	5 million
Pelagic Cormorant		90,000
Cormorant	250,000	
Harlequin Duck		600,000 to 1 million
Dabbling Duck	2 to 5 million	
Diving Duck	2 to 3 million	
Tundra Swan	At least 11,200	
Red-faced Cormorant		About 130,000
Dusky Canada Goose		13,000
Glaucous-winged Gull	500,000	229,000 – 500,000
Black tailed Kittiwae	2.5 million	2 to 2.5 million
Red-legged Kittiwae	226,802	
Arctic Tern		25,000
Murre	7 million	
Common Murre		1.6 to 3.5 million
Thick-billed Murre		3.5 to 4 million
Pigeon Guillant		40,000 to 200,000
Ancient Murrelet		400,000
Horned Puffin	1.5 million	1.5 million
Tufted Puffin	4 million	2 to 4 million
Bald Eagle	30,000 to 55,000	30,000 to 35,000
Peale's Peregrine Falcon		1.2 million minimum
Least Auklet	3.4 million	
Whiskered Auklet	50,000	

Sources:
[1] Alaska Habitat Management Guides, Southcentral, Southwest, Southeast, Western, and Interior Regions: Distribution, Abundance, and Human Use of Fish and Wildlife, Alaska Department of Fish and Game, 1985, provides regional and statewide estimates of populations for selected species.

[2] Alaska Environmental Information and Data Center, "Wildlife Populations of Prince William Sound: A Synthesis of the Open Literature," June 1990 includes estimates of statewide populations for selected species.

Table 11: Summary of Significance of Major Species of Birds in Alaska (adapted from U.S. Fish and Wildlife Migratory Bird Program)
Shorebirds
71 documented species of shorebirds have occurred in Alaska.
46 species have been documented breeding in Alaska; shorebirds constitute 17.6 % of all birds breeding in Alaska.
36 species are common, regular breeders; 10 species are irregular breeders or breed in small numbers.
40 of the 46 breeding species (87%) nest nowhere else in the United States.
23 species nest only on coastal and alpine tundra in arctic and subarctic regions.
Most of the world's population of 3 species (Bristle-thighed Curlew, Black Turnstone and Western Sandpiper) and 4 subspecies (Dunlin [pacifica], Rock Sandpiper [ptilocnemis and couesi], and Short-billed Dowitcher [caurinus] nest in Alaska.
Alaska hosts 100% of the western hemisphere populations of the Pacific Golden-Plover, Bar-tailed Godwit, and Red Knot.
75% of the world's populations of Surfbirds and a race of Rock Sandpipers (tschuktschorum) breed in Alaska.
Alaska supports 50% of the world's population of Black Oystercatchers, Wandering Tattlers, Whimbrels (hudsonicus), and Hudsonian Godwits (haemastica).
Shorebirds that breed in Alaska travel to Australia, South Pacific Islands, Africa, Southeast Asia, the lower 48, Central America, and South America to spend the winter.
Only 7 species remain in Alaska, in any numbers, during the winter (Black Oystercatcher, Black Turnstone, Surfbird, Sanderling, Rock Sandpiper, Dunlin, and Common Snipe).
Seabirds
About 50 million seabirds nest on Alaska's coast each summer. This is 87% of all the seabirds in the United States. Alaska's seabirds nest in more than 1600 seabird colonies around the coast.
There are four main groups of seabirds in Alaska: Tubenoses (albatrosses and their relatives); Pelicans and cormorants (Alaska has only cormorants); Gulls, terns, kittiwakes, and their relatives; and Auks (puffins and their relatives).
Many of Alaska's seabird species also nest across the Arctic, from Canada to Norway. Eight Species nest only in Alaska and in nearby parts of Russia. These include the red-faced cormorant, the red-legged kittiwake, and whiskered auklet.
Raptors
Twenty-one of 28 species of raptors recorded in Alaska are common breeders.
Alaska is recognized nationally as a stronghold for bald eagles, especially in Southeast Alaska and many coastal areas.
Bald eagles from Alaska have been used for successful eagle reintroduction efforts in several states.
Gyrfalcons, listed as a CITES species (highly regulated international trade), are common breeders in much of Alaska.
Except for bald eagles and the 2 species of threatened/endangered peregrine falcons (American and Arctic), very little is known about raptor populations in Alaska.

Table 11 continued: Summary of Significance of Major Species of Birds in Alaska
Landbirds
Landbirds (birds other than waterfowl, shorebirds or seabirds) are an important part of the avian diversity of Alaska. Because of its geographical position, Alaska has a unique mix of landbirds that is duplicated nowhere else in the world.
Landbirds constitute 51% of all bird species that breed in Alaska (262 species) and include 90 species of songbirds.
Most landbirds (77%, or 103 species) migrate out of Alaska for the winter.
Within the United States, more than 75% of the breeding ranges of the Gray-cheeked Thrush, Alder Flycatcher, Blackpoll Warbler and Northern Waterthrush, species that migrate to the American tropics, occur in Alaska.
The U.S. breeding ranges of several other species (e.g., Smith's Longspur, McKay's Bunting, Golden-crowned Sparrow) are essentially confined to Alaska.
Some species that are found in restricted habitats in other states (e.g., Wilson's Warbler) are much more widespread in Alaska.
Landbirds are found in all terrestrial habitats that occur in Alaska: Surprisingly, 31 landbird species (23%) choose to spend their winter in Alaska. As you might expect, most of Alaska's winter landbird residents are grouse, owls and woodpeckers (18 species). Away from the coast, however, birds are often hard to find. Christmas Bird Counts in central Alaska seldom reach 20 species and are dominated by Common Ravens, Black-capped and Boreal Chickadees, and Common Redpolls. The only species unique to Alaska, the McKay's Bunting, leaves its breeding sites on islands in the Bering Sea to pass the winter on the mainland coast of western Alaska.
Waterfowl
Alaska has 90+ million acres of wetland habitat for use by breeding waterfowl.
About 20% of America's waterfowl nest here. At least 42 species are known to nest in the state regularly. Over half a million geese of 5 species and 10 subspecies nest in the state annually.
Up to half of North America's Pintail ducks nest here. Over 80% of the world population of breeding Pacific Black Brant fly to Alaska each year to nest. Most of these fly to the Yukon-Kuskokwim Delta.
Nine out of ten of the world's Emperor Geese nest here. Again, nearly all of these are on the Yukon-Kuskokwim Delta.
Alaska supports 100% of the world's breeding Tule and Pacific White-Fronted Geese Aleutian, Cackling and Dusky Canada Geese.
Alaska supports 100% of the U.S. breeding populations of several northerly species of seaducks: 4 species of eiders Spectacled Eiders, King Eiders, Common Eiders, and Steller's Eiders), Oldsquaw, and 3 species of scoters, Black Scoters, White-Winged Scoters, and Surf Scoters.
More than 90,000 Tundra Swans and 13,000 Trumpeter Swans nest in this area. Five species of loons nest in Alaska. The state is home to 100 of the U.S. breeding populations of Pacific, Arctic, Red-Throated, and Yellow-Billed Loons.
Source: U.S. Fish and Wildlife Migratory Bird Program Web Pages at http://www.r7.fws.gov/mbm/mbmpg1.html

4. Fish

Commercial fisheries in Alaska harvest salmon, halibut, herring, shellfish, and groundfish and sell them for food or as processed products. Many coastal communities in Alaska rely on commercial fishing for income and for employment, and many residents of these communities consider fishing to be their traditional lifestyle that has been passed on to them from previous generations. Besides its value as a commercial commodity, sport fishers and subsistence users catch a variety of fresh and salt-water fish for food or trophies. Fish are also an important link in the ecosystem providing food for other animals such as bears and marine mammals.

The annual abundance of fish in Alaska is measurable by total number of fish caught *plus* the number of fish that are not caught each year (called escapements). Estimates of the abundance and health of fish and their habitat are available only for particular species in selected streams, rivers, lakes, and areas of the ocean in Alaska. There are few comprehensive accounts of the abundance and health of particular fish species throughout the state.

As an alternative, for purposes of this broad overview, we can use the total number of fish *caught* as a general indicator of the abundance of fish. However, it is important to remember that estimates of the number of fish *caught* understate the total population of fish and do not necessarily indicate whether the total population of fish is increasing or decreasing. With these limitations in mind, Figure 5 shows the total volume of fish caught in Alaska in the commercial fisheries for salmon, halibut, herring and shellfish over time. Besides these commercial harvests of fish, sport fishers and subsistence users also harvest fish as summarized in Table 12.

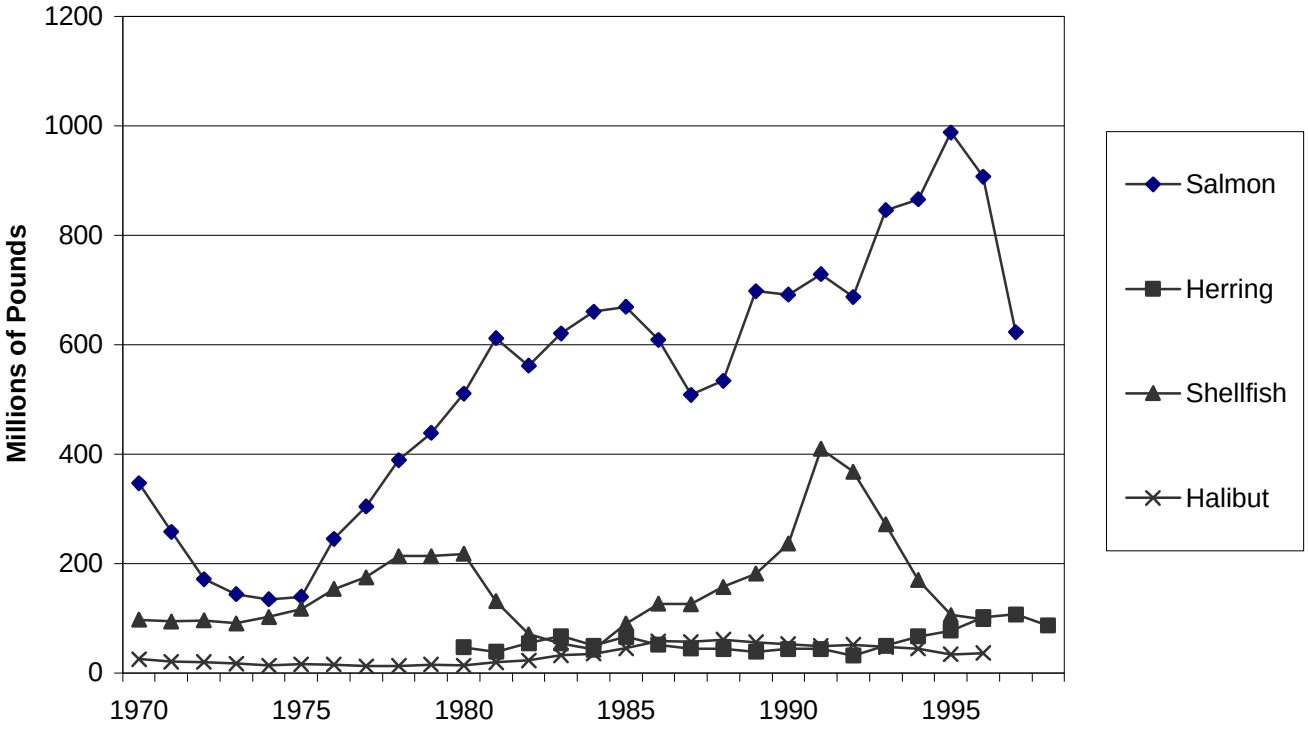
The commercial groundfish fisheries in the Gulf of Alaska, Bering Sea, and along the Aleutians catches volumes of fish substantially larger than the other fisheries and would be off the scale of Figure 5. Figure 6 shows the total volume of all species of groundfish harvested, including mostly pollock, cod, and smaller amounts of flatfish, flounder, sole, sablefish, and other groundfish species. The total volume of fish caught in the groundfish fishery is about twice the total volume of all other types of fish caught in all other Alaska commercial fisheries combined.

The groundfish fisheries also catch other species as bycatch, including halibut, red king crab, bairdi crab, chinook salmon, and other species of salmon. Most of this bycatch is discarded since it is not the targeted species of the groundfish fishery. About one third of this halibut bycatch and most of the salmon and crab do not survive after they are discarded.

- For more information about commercial fisheries in Alaska, see the fisheries information page at the Alaska Department of Fish and Game, Commercial Fishing Division at http://www.cf.adfg.state.ak.us/cf_home.htm.

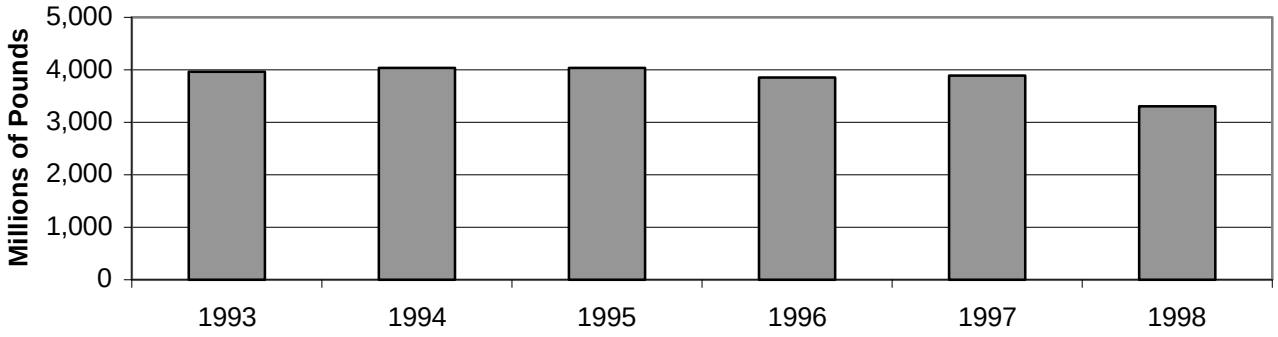
- More information about sport fishing and subsistence activity is available at the Alaska Department of Fish and Game page at http://www.state.ak.us/adfg/adfghome.htm.

Figure 5: Volume of Fish and Shellfish Harvested in Alaska Commercial Fisheries, not including Groundfish



Source: Alaska Department of Fish and Game, Division of Commercial Fisheries

Figure 6: Volume of Groundfish Harvested in Gulf of Alaska, Bering Sea, and Aleutians



Source: National Marine Fisheries Service, Gulf of Alaska Groundfish Quotas and Preliminary Catch in Round Metric Tons and Bering Sea & Aleutians Groundfish Quotas and Preliminary Catch in Round Metric Tons, various years, 10/22/98 availabile online at http://www.fakr.noaa.gov/

Table 12: Summary of Sportfish and Subsistence Fish Harvest in Alaska

Sports Fishing Harvest in 1996		**Number of fish harvested in 1996**
All Salmon Species		1,264,164
Trout		147,425
Halibut		333,981
Dolly Varden		63,991
Arctic Grayling		37,238
Rockfish		83,434
Razor Clams		1,308,770
All Other Fish		97,770
Annual Subsistence Fish Harvest during 1990's		**Average pounds of fish harvested annually**
Rural Subsistence	Fish	25,783,000
	Shellfish	874,000
Urban Subsistence	Fish	6,664,000
	Shellfish	49,000

Sources: Allen L. Howe, Gary Fidler, Cynthia Olnes, Allen E. Bingham, and Michael Mills, *Harvest, Catch, and Participation in Alaska Sport Fisheries During 1996*. , Division of Sport Fish, Alaska Department of Fish and Game, November 1997.

Robert Wolfe, *Subsistence Food Harvests in Rural Alaska, and Food Safety Issues,* paper presented to the Institute of Medicine, National Academy of Sciences Committee on Environmental Justice, Spokane Washington and available online at http://www.state.ak.us/local/akpages/FISH.GAME/subsist/subsist/download/food962.pdf.

5. Endangered Animals

Several animals are of particular concern because their populations or their habitat is threatened. The U.S. Fish and Wildlife, National Marine Fisheries Service, and Alaska Department of Fish and Game monitor endangered species in Alaska. A species is classified as endangered if it is in danger of extinction throughout all or a significant portion its range. A species is "threatened" if it is likely to become endangered within the near future throughout all or a significant portion of its range. A species receives a “proposed” classification if it is formally proposed for listing as endangered or threatened in the Federal Register. A species that has been removed from the list of threatened and endangered species is classified as “delisted.” The Fish and Wildlife Service will monitor these "delisted" species for a period of at least five years following "delisting." The endangered species in Alaska are listed in Table 13.

For more information about endangered animals,

- U.S. Fish and Wildlife Service, has a list of Endangered Species and more information about their range and current status at http://www.fws.gov/r9endspp/endspp.html.

- Alaska Natural Heritage Program is developing an inventory of rare plant and animal species in Alaska. They have detailed species lists, and information about particular species at http://www.uaa.alaska.edu/enri/aknhp_web/.

Table 13: Endangered, Threatened, and Candidate Species in Alaska

Listed Species			Status
Common Name		Scientific Name	
Birds	Aleutian Canada goose	*Branta canadensis leucopareia*	Threatened
	American peregrine falcon	*Falco peregrinus anatum*	Endangered
	Eskimo curlew	*Numenius borealis*	Endangered
	Short-tailed albatroos	*Diomedea albatrus*	Endangered
	Spectacled eider	*Somateria fischeri*	Threatened
	Steller's eider	*Polysticta stelleri*	Proposed
	Arctic peregrine falcon tundrius	*Falcoperegrinus*	Delisted
Plants	Aleutian shield fern	*Polystichum aleuticum*	Endangered
Mammals	Northern right whale	*Balaena glacialis*	Endangered
	Bowhead whale	*Balaena mysticetus*	Endangered
	Sei whale	*Balaenoptera borealis*	Endangered
	Blue whale	*Balaenoptera musculus*	Endangered
	Fin whale	*Balaenoptera physalus*	Endangered
	Humpback whale	*Megaptera novaeangliae*	Endangered
	Sperm whale	*Physeter macrocephalus*	Endangered
	Steller sea lion	*Eumetopias jubatus*	Threatened
	Gray whale (effective June 16, 1994)	*Eschrichtius robustus*	Delisted
Fishes	Snake River sockeye salmon	*Oncorhynchus nerka*	Endangered
	Snake River spring/summer chinook salmon	*Oncorhynchus tshawytscha*	Threatened
	Snake River fall chinook salmon	*Oncorhynchus tshawytscha*	Threatened
Reptiles	Green sea turtle	*Chelonia mydas (incl. agassizi)*	Threatened
	Leatherback sea turtle	*Dermochelys coriacea*	Endangered
	Loggerhead sea turtle	*Caretta carretta*	Threatened
	Olive (Pacific) ridley sea turtle	*Lepidochelys olivacea*	Threatened

Source: U.S. Fish and Wildlife Service and National Marine Fisheries Service, May 1996, as reported at the U.S. Fish and Wildlife web site http://www.fws.gov/r9endspp/endspp.html.

For more information about Alaskan animals in general,

- Alaska Natural Heritage Program is developing an inventory of all plant and animal species in Alaska. They have detailed species lists, and information about particular species at http://www.uaa.alaska.edu/enri/aknhp_web/.

- U.S. Geological Survey, Alaska Biological Science Center Research Program studies Alaska ecosystems and a variety of Alaska animal species and provides online information at http://www.absc.usgs.gov/research/

- The Alaska Department of Fish and Game, Conservation Division has put their Alaska Wildlife Notebook series online at http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm.

- *The Nature of Alaska: An Introduction to Familiar Plants and Animals and Natural Attractions*, Waterford Press, 1997.

- Susan Ewing, *The Great Alaska Nature Factbook: A Guide to the State's Remarkable Animals, Plants, and Natural Features,* Alaska Northwest Books, 1996.

- Edward T. LaRoe, Gaye S. Farris, Catherine Puckett, Peter Doran, Michael Mac, editors, *Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of our Living Resources,* U.S. Department of Interior, National Biological Service, Washington D.C., 1995.

E. Open Spaces

Open space in Alaska includes all land with limited or no human development such as parks, refuges, wildlife habitats, preserves, and other undeveloped public or private land. Open space is a valuable natural asset that provides life-support services and habitat for wildlife. Open space provides residents with outdoor recreation opportunities and is one of the primary natural attractions drawing tourists to Alaska. Many people value the existence of open space even if they never visit it while others value the opportunity of leaving open land as a bequest to future generations.

Table 14 lists the primary public open spaces in Alaska. Public open spaces include federal lands such as national parks, wildlife refuges, parts of national forests, historic parks, national monuments, national preserves, and parts of Bureau of Land Management (BLM) lands. In addition, there are public open spaces on state lands, including state parks, state refuges, state critical habitat areas, state sanctuaries, and state forests. Some of these open areas are designated as wilderness areas with restrictions on the level of development and human activity. Other areas are managed primarily as habitat for wildlife. State and national forest are managed for timber harvest, recreational use, and wildlife habitat. State and national parks and national monuments are managed to preserve natural wonders, wildlife habitat, and recreational use.

For more information about open space in Alaska, see

- The Alaska Public Lands Information Office provides a map and more information about public lands in Alaska at http://www.nps.gov/aplic/land_map/index.html.

- The U.S. Fish and Wildlife Service Wetlands site describes wetlands throughout the United States, including Alaska and is available online at http://www.nwi.fws.gov/.

- The Alaska Department of Fish and Game, Habitat Division provides a description of state managed wildlife habitat at http://www.state.ak.us/local/akpages/FISH.GAME/habitat/hab_home.htm.

- The Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation provides more information about state parks at http://www.dnr.state.ak.us/parks/.

Table 14: Public Open Space in Alaska

Type of Land	Name	Total Acres	Designated Wilderness Acres	Primary Features
National Forests	Total	21,347,359	575,321	
	Chugach National Forest	4,392,646		Coastal forest habitat, wildlife, backcountry recreation, forestry
	Tongass National Forest	16,954,713	575,321	Coastal forest habitat, wildlife, backcountry recreation, forestry
National Parks	Total	38,142,000	32,848,564	
	Denali National Park	6,028,000		Mount McKinley, abundant wildlife
	Gates of the Arctic National Park and Preserve	8,472,000		Brooks Range, wild and scenic rivers, wildlife
	Katmai National Park and Preserve	4,090,000		Valley of Ten Thousand Smokes, brown bears
	Kenai Fiords National Park	570,000		Fjords, Harding Icefield, Exit Glacier, waterfowl, sea otters
	Kobuck Valley National Park	1,750,000		Archeological sites, Great Kobuck Sand Dunes, river rafting
	Lake Clark National Park and Preserve	4,044,000		Backcountry recreation, fishing, scenery
	Wrangell-St.Elias National Park and Preserve	13,188,000		Rugged peaks, glaciers, expansive wilderness
National Historical Parks	Total	2,827		
	Klondike Gold Rush National Historical Park	2,721		Chilkoot Trail
	Sitka National Historical Park	106		Russian Bishop's House, totems, trails
	Unalaska Aleutian WW II National Historic Area			
National Monuments	Total	1,263,000		
	Aniakchak National Monument and Preserve	603,000		Aniakchak dry caldera
	Cape Krusenstern National Monument	660,000		Archaeology sites
National Preserves	Total	11,882,000		
	Bering Land Bridge National Preserve	2,785,000		Lava fields, rare plants, archeology sites, migratory water fowl
	Noatak National Preserve	6,574,000		Abundant wildlife, river floating
	Yukon Charley Rivers Preserve	2,523,000		Backcountry recreation, river floating

Table 14 Continued: Public Open Space in Alaska				
Type of Land	**Name**	**Total Acres**	**Designated Wilderness Acres**	**Primary Features**
National Wildlife Refuges	Total	76,816,502	18,280,976	Habitat for wildlife
	Alaska Maritime National Wildlife Refuge	3,435,639	2,373,976	Seabirds, sea lions, sea otters, harbor seals, walrus
	Alaska Peninsula National Wildlife Refuge	3,500,000		Brown bears, caribou, moose, sea otters, bald eagles, peregrine falcons, wolves, wolverines, migrating whales
	Arctic National Wildlife Refuge	19,575,711	8,000,000	Caribou, polar bears, grizzly bears, wolves, Dall sheep, peregrine falcons, musk oxen, snowy owls.
	Becharof National Wildlife Refuges	1,200,000	477,000	Brow bears, bald eagles, caribou, moose, salmon
	Innoko National Wildlife Refuge	3,850,000	1,240,000	Migratory waterfowl, beaver, lynx, marten, moose
	Izembek National Wildlife Refuge	303,094	30,000	Black brant (coastal geese), brown bears
	Kanuti National Wildlife Refuge	1,430,000		Waterfowl
	Kenai National Wildlife Refuge	1,904,757	1,350,000	Moose, salmon, mountain goats, Dall sheep, bears, lynx, wolves
	Kodiak National Wildlife Refuge	1,768,577		Brown bears, black-tailed deer, bald eagles, river otter
	Koyukuk National Wildlife Refuge	3,550,000	400,000	Wolves, caribou, bear, moose
	Nowitna National Wildlife Refuge	1,560,000		Migratory waterfowl, caribou, moose, bears, furbearers
	Selawik National Wildlife Refuge	2,150,000	240,000	Caribou, migratory birds
	Tetlin National Wildlife Refuge	729,648		Migratory waterfowl, Dall sheep, moose, bear, ptarmigan
	Togiak National Wildlife Refuge	4,097,431	2,270,000	Nearly every major wildlife species of Alaska represented
	Yukon Delta National Wildlife Refuge	19,131,645	1,900,000	Migratory birds, musk oxen and reindeer on Nunivak Island
	Yukon Flats National Wildlife Refuge	8,630,000		Waterfowl, moose, caribou, bear

Table 14 Continued: Public Open Space in Alaska				
Type of Land	**Name**	**Total Acres**	**Designated Wilderness Acres**	**Primary Features**
Bureau of Land Management	Total	150,000,000		
	Arctic District surface	34,000,000		wildlife, archaeology and paleontological sites, subsistence
	Arctic District subsurface	70,000,000		subsurface oil, gas, coal, minerals
	Kobuck District	17,000,000		reindeer, outdoor recreation, fishing, hunting, subsistence
	Steese-White Mountains District	7,500,000		White Mountains National Recreation Area, Steese Mountain Conservation Area, Pinnell Mountain National Recreation Trail, Fort Egbert National Historic Site, wild and scenic rivers, recreation, mining, subsistence
	Glennallen District	5,500,000		recreation, fisheries, wildlife habitat, cultural resources, right of ways
	Anchorage District	16,000,000		Campbell Tract in Anchorage, Iditarod National Historic Trail, realty, wildlife, recreation, mining.
State Park System	Total	3,177,677		Outdoor Recreation
	State Parks			Accessible wilderness, backcountry recreation, camping, fishing, hiking
	Chugach	495,204		
	Denali	324,240		
	Chilkat	6,045		
	Kachemak Bay Park and Wilderness Park	328,290		
	Point Bridget	2,800		
	Shuyak Island	11,000		
	Afognak Island	48,742		
	Wood-Tikchik	1,555,200		
	Kenai River Special Management Area	2,170		Fishing
	Alaska Chilkat Bald Eagle Preserve	49,320		World's largest concentration of bald eagles
	33 Marine Parks	55,657		Fishing
	47 Recreational Sites, 15 Recreation Areas, 6 Historic Parks, 3 Historic Sites, and 2 State Trails	299,009		Outdoor recreation

Table 14 Continued: Public Open Space in Alaska

Type of Land	Name	Total Acres	Designated Wilderness Acres	Primary Features
State Forests	Total	2,036,930		
	Tanana Valley State Forest	1,786,330		habitat, timber, and recreation
	Haines State Forest	250,600		habitat, timber, and recreation
State Refuges	Cape Newenhan			waterfowl and other wildlife habitat
	Izembek			waterfowl and other wildlife habitat
	Trading Flats			fish and wildlife habitat
	Susitna Flats			fish and wildlife habitat
	Anchorage Coastal			waterfowl, shorebirds, salmon,
	Goose Bay			waterfowl and other wildlife habitat
	Palmer Hay Flats			waterfowl and other wildlife habitat
	Minto Flats			fish and game habitat
	Creamer's Field			migratory bird habitat
	Yakataga			wildlife habitat
	Mendenhall Wetlands			waterfowl and other wildlife habitat
	McNeil River			brown bear, fish, and other wildlife habitat
State Critical Habitat Areas	Eqegik			waterfowl and other wildlife habitat
	Pilot Point			waterfowl and other wildlife habitat
	Cinder River			waterfowl and other wildlife habitat
	Port Heiden			waterfowl and other wildlife habitat
	Port Moller			waterfowl and other wildlife habitat
	Tugidak Island			marine mammal, birds, fish, shellfish
	Kalgin Island			waterfowl and other wildlife habitat
	Redoubt Bay			Tule geese and other wildlife habitat
	Willow Mountain			fish and wildlife habitat
	Clam Gulch			razor clam, fish, and other wildlife habitat
	Anchor River and Fritz Creek			moose, fish, and other wildlife habitat
	Fox River Flats			shorebird, waterfowl, and other wildlife habitat
	Kachemak Bay			shellfish, crab, and fish habitat
	Copper River Delta			waterfowl, shorebirds, other wildlife habitat
	Dude Creek			lesser sandhill cranes wet meadow habitat
	Chilkat River			eagle resting and feeding habitat
State Sanctuaries	Walrus Island			walrus and other wildlife habitat
	McNeil River			brown bear, fish and other wildlife habitat
	Stan Price			brown bear, fish and other wildlife habitat

Table 14 Continued: Public Open Space in Alaska

Type of Land	Name	Total Acres	Designated Wilderness Acres	Primary Features
Wild and Scenic Rivers Within the National Park Areas	Alatna			Katmai National Park
	Aniakchak			Gates of the Arctic National Park
	Charley			Yukon-Charley Rivers National Preserve
	Chilikadrotna			Lake Clark National Park and Preserve
	John			Gates of the Arctic National Park
	Kobuck			Gates of the Arctic National Park
	Mulchatna			Lake Clark National Park and Preserve
	Noatak			Gates of the Arctic and Noatak National Preserves
	North Fork Koyukuk			Gates of the Arctic National Park
	Salmon			Kobuck Valley National Park
	Tinayguk			Gates of the Arctic National Park
	Tlikakila			Lake Clark National Park and Preserve
Wild and Scenic Rivers within National Wildlife Refuges	Andreafsky			Yukon Delta National Wildlife Refuge
	Ivishak			Arctic National Wildlife Refuge
	Nowitna			Nowitna National Wildlife Refuge
	Selawik			Selawik National Wildlife Refuge
	Sheenjek			Arctic National Wildlife Refuge
	Wind			Arctic National Wildlife Refuge
Wild and Scenic Rivers within BLM Units or outside designated areas	Beaver Creek			White Mountains National Recreation Area
	Birch Creek			near Steese Highway
	Delta River			Tangle Lakes to just north of Black Rapids
	Fortymile River			Main stem within Alaska including tributaries
	Gulkana River			Main Stem from Paxson Lake to Sourdough Creek
	Unalakleet River			About 80 miles of the main stem

Sources:
Alaska Department of Fish and Game, Habitat Division, *State of Alaska Refuges, Critical Habitat Areas, and Sanctua*ries, March 1991,
Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, *Alaska State Park*s, January 1997,
U.S. Department of Interior, Bureau of Land Management, *BLM Alaska: The Public Lands in Alaska Administered by BLM*, 1997,
U.S. Department of Interior, Fish and Wildlife Service*, Wild Things, Wild Places: National Wildlife Refuges in Alaska*, 1998,
U.S. Department of Interior, National Park Service, *National Parklands in Alaska: Official Map and Guide*, 1998,
Alaska Almanac, Alaska Facts, 1996.

F. Environmental Quality

As discussed earlier, we rely the ecosystem for life support services such as clean air to breath, water to drink, and land for growing food. It is difficult to quantify or measure all of these assets since air and water naturally flows across Alaska's boundaries to and from the sea and atmosphere. However, we can assess the *quality* of the air, water, and land in Alaska. Measurements of environmental quality provide indications of degradation of the ability of the air, water, and land to provide life support services. When we reduce the ability of the air, water, or land to provide these services, we effectively decrease our reserves of natural assets

1. Water Quality

In 1996, the Alaska Department of Environmental Conservation (ADEC) completed a comprehensive study of the major sources of water pollution in Alaska.[18] As listed in Table 15, their report identifies urban development, seafood processing, oil and gas development, oil transportation, mining, and forest products industries as the major sources of water pollution in Alaska. For each of these industries, they monitor their waste discharges, the bodies of water they affect, and why the discharges are of concern. The ADEC report also identifies particular bodies of water that are contaminated and under review for procedures to remove the sources of water pollution. Table 16 summarizes the bodies of water identified as most threatened by water pollution. These bodies include mostly creeks, rivers, and bays that are close to industrial activity or urban areas.

2. Air Quality

The Alaska Department of Environmental Conservation completed their most recent comprehensive assessment of air quality in Alaska in 1991.[19] In their report, the ADEC identified carbon monoxide, particulate matter, and nitrogen oxide as pollutants that they monitor to ensure that Alaska complies with national standards for ambient air quality. Carbon monoxide is a colorless, odorless, and poisonous gas produced by an incomplete burn of carbon in fuels. In Anchorage and Fairbanks, 90% of wintertime carbon monoxide comes from motor vehicles.

Particulate matter is the most noticeable form of air pollution consisting of dust, small particles of dirt, smoke, and airborne chemicals in the form of liquid droplets. Larger particles come from unpaved roads, fugitive dust, agricultural activities, and surface mines. Smaller particles generally come from smoke stacks, motor vehicles, and chemical processes which emit gases such as sulfur dioxide and volatile organic compounds. Natural sources of particulate include windblown dust and ash from forest fires and grass fires. [20]

3. Hazardous Wastes

The Alaska Department of Environmental Conservation monitors pollutants and wastes that are toxic or hazardous to public safety and health. The most common hazardous wastes produced in Alaska are toxic cleaners, degreasers, solvents, chlorinated compounds, paints, coatings, and flammable liquids, used oil, oily rags, waste fuels, batteries, acids, contaminated soils, cleanup wastes, and waste drilling or clean-up sludges. These hazardous wastes are

regulated to ensure that they are recycled or disposed of in ways that reduce the threat to public health and the environment.[21]

The ADEC monitors sites in Alaska contaminated by hazardous substances that have not been disposed properly.[22] As of July 1994, the ADEC identified about 1100 contaminated sites.[23] Based on ranking of the severity of risk to public health and the environment, approximately 250 sites have been determined to be high priorities for cleanup. In addition there are eight "superfund" sites in Alaska that have been identified by the federal Environmental Protection Agency (EPA) as some of the worst in the nation and have slated them for major federal cleanup actions.

Contaminated sites may be associated with military, commercial or industrial activities, mining, and a variety of smaller enterprises where hazardous materials were used. Many different types of hazardous substances are found at contaminated sites in Alaska. Sites contaminated by petroleum products are by far the most common. Other contaminated sites have chlorinated solvents, heavy metals, synthetic organic pesticides, non-chlorinated solvents, and inorganic acids and bases.[24]

These hazardous substances pose a range of threats to human health. Many of the chlorinated hydrocarbons and some of the heavy metals are carcinogenic. Exposure to other compounds can cause a wide range of acute and chronic health problems. Toxic wastes can also threaten the ecological health of an ecosystem and threaten forests, vegetation, fish, and other animals.

- The U.S. Geological Survey Water Resources Division provides more detailed information about water resources in Alaska at their web page, http://www-water-ak.usgs.gov/ .

- For more information on water quality in Alaska, see the water quality report by DEC titled, *Alaska's 1996 Water Quality Assessment Report*, Alaska Department of Environmental Conservation, August 1996.

- The U.S. Environmental Protection Agency discusses the extent, costs, and significance of various forms of water and air pollution at their "Economy and Environment" web site at http://www.epa.gov/docs/oppe/eaed/eedhmpg.htm.

- For more information on air quality in Alaska, see *Air Quality in Alaska, January 1989 – June 1990*, Alaska Department of Environmental Conservation, Air Quality Management Section, 1990.

- For more information about contaminated sites in Alaska, see the Department of Environmental Conservation web site at http://www.state.ak.us/local/akpages/ENV.CONSERV/dspar/csites/csitesf.htm.

Table 15: Sources of Water Pollution in Alaska

Type	Areas	Sources	Water Affected	Reasons for Concern
Urban Development	Anchorage Juneau Fairbanks	Onsite sewage disposal, domestic animal wastes, hazardous or toxic substances, leaked petroleum products, landfills, nutrient introduction, storm water runoff erosion and sedimentation of disturbed surfaces, modification of shores , loss of wetlands	Lakes, Ponds, Streams, Estuaries, Harbors, Wetlands, Ground waters	Threat to public health and the environment Public Nuisance Aesthetic Detriment Difficult and expensive to restore waters once they are degraded.
Seafood Processing	Onshore processing Offshore moored Offshore mobile	Sea life material remaining after processing such as heads, skin, scales, viscera, tail fins, and shells that are ground and discharged as solid and liquid waste effluent	Seafood waste solids accumulated on the ocean floor Seafood processing effluent remaining suspended in water column	Smothers aquatic life Reduced oxygen in surrounding waters Decomposition increases oxygen demand in water column Reduces oxygen in surrounding water column
Oil and Gas Development and Trans-portation	North Slope Cook Inlet Prince William Sound	Point Sources such as shore based-refineries, ballast water facilities, and offshore platforms Non-Point sources such as road improvements, spills, culvert washouts, drainage alterations, pad runoff, reserve pit leachates, offshore causeways, gravel mining, pipelines, gravel fill in wetlands	Rivers, streams, lakes, wetlands, estuaries, Beaufort Sea, Cook Inlet, Kenai Peninsula waters, Coastal waters of Prince William Sound	Degradation of water quality from point and non-point sources

Source: Alaska Department of Environmental Conservation, *Alaska's 1996 Water Quality Assessment Report*, August 1996.

Table 15 Continued: Sources of Water Pollution in Alaska

Type	Areas	Sources	Water Affected	Reasons for Concern
Mining	Areas near mining sites	Point sources from discharge of mine drainage wastewater. Non-point source from erosion of active and abandoned mine sites from stream flow, modification and diversion of stream channels, erosion and runoff from upland disturbed surfaces, overburden and tailings, and erosion and runoff from associated activities such as roads and camps.		Restrict light penetration and plant productivity, cover aquatic habitat, spawning areas, and food sources, reduce fish egg and fry survival, restrict fish feeding and movement, interfere with birds and wildlife, carry absorbed toxic heavy metals, sedimentation affects human drinking water sources, subsistence uses, and recreation
Forest Products	Throughout forested areas in the State, but mostly Southeast	Industrial Facilities: pulp mill wastes including sediment, dissolved oxygen, color, and toxic substances	Nearby harbors and bays	Degradation of marine life habitat
		Log transfer facilities bark debris	Estuaries, ocean floor	Bark debris smoothers bottom habitat of ocean floor, lowering of dissolved oxygen from bark decomposition, leaching of organic compounds from bark, production of hydrogen sulfide and ammonia.
		Timber harvesting: Sedimentation from landslides induced by heavy rainfall on steep slopes with unstable soils	streams	Sedimentation covers streambeds, reduces dissolved oxygen, impedes egg development, reduces fry size, impedes fry emergence, covers and hides food sources, reduce plant and invertebrate productivity, slow growth rates of fish, abrade the gills of fish, cause avoidance of affected waters. Erosion removes critical habitat.
		Timber harvest: vegetative debris	Streams	Harvest of streamside trees prevents or reduces future accumulation of woody debris in streams. The loss of in-stream woody debris can result in decreased retention and sorting of substrate materials and loss of pool habitat.

Source: Alaska Department of Environmental Conservation, *Alaska's 1996 Water Quality Assessment Report*, August 1996.

Table 16: High Priority Water Quality-Limited Waterbodies in Alaska in 1996

Waterbody	Location	Pollutant Parameters	Pollutant Sources
Tier I: Water Quality Limited waterbodies that require water quality assessments to verify the extent of pollution and what controls are in place or needed.			
Naknek River	King Salmon	Petroleum Hydrocarbons, Metals	Landfill, Fuel Storage
Eskimo Creek	King Salmon	Petroleum Hydrocarbons, Metals, Pesticides, Tricholoroethylene	Landfill, Fuel Storage
King Cove	King Cove	Seafood Residue	Seafood Processing / Waste
Popof Strait	East Aleutians Borough	Seafood Residue	Seafood Processor
Ship Creek -- Glenn Highway to mouth	Anchorage	Fecal Coliform, Petroleum Products	Urban Runoff
Thorne Bay	Prince of Wales Island	Debris, Hydrogen Sulfide	Log Transfer Facility
Shoemaker Bay	Wrangell	Debris	Industrial
Rowan Bay	Kuiu Island	Debris	Log Transfer Facility
Hamilton Bay	Kake	Debris	Log Transfer Facility
Red Dog Creek/ Ikalukarok Creek	Near Red Dog Operation	Total Dissolved Solids	Mining
Tier II: Water quality limited water bodies that have completed water quality assessments and now require water body recovery plans. Recovery plan not yet implemented.			
Ward Cove	Ketchikan	Sediment, Dissolved Oxygen, Color, Toxic Substances	Industrial
Akutan Harbor	Akutan Island	Settleable Solids, Dissolved Oxygen	Seafood Processing Wastes
Red Fox Creek	King Salmon	Petroleum Hydrocarbons, Metals	Landfill, Fuel, Storage
King Salmon Creek	King Salmon	Petroleum Hydrocarbons, Metals, Pesticides	Landfill, Fuel, Storage
Birth Creek Drainage	North of Fairbanks	Turbidity	Placer Mining
Silver Bay	Sitka	Dioxin, Sludge, Dissolved Oxygen	Industrial

Source: Alaska Department of Environmental Conservation, *Alaska's 1996 Water Quality Assessment Report,* August 1996.

III. Measuring the Value of our Natural Assets

There are many different ways that we value natural assets. Some assets have *market value* as commodities. For example, as consumers, we value oil as gasoline and as an ingredient for a myriad of products; we consume timber as lumber, paper, and wood products; and we eat commercial fish as food or processed products. Other parts of nature have *consumptive use value* even though they are not sold in the market. Non-market consumptive uses include sporthunting, sportsfishing, and subsistence consumption of fish and game as food, trophies, and other uses.

Natural assets are also valuable for *non-consumptive uses* that do not consume or deplete the assets. Non-consumptive uses include outdoor recreation such as skiing, hiking, camping, wildlife viewing and other activities that do not consume or diminish natural assets. In addition, much of the Alaskan tourism industry is based on tourists coming to the state to enjoy non-consumptive uses of our natural assets.

More broadly, natural assets are valuable even if we do not use or visit them. These *non-use values* include the value of wildlife in their natural habitat, the value of undeveloped wilderness, the value of leaving natural wonders as bequests to our children, and many other cultural values that natural assets hold regardless of whether we use or visit them.

In this section, we describe the market value, consumptive-use value, non-consumptive-use value, and non-use value of natural assets in more detail. We also present quantitative monetary estimates of the value of selected natural assets.

A. Market Value of Commodities

Natural resources such as oil, timber, fish, minerals, crops, and livestock are bought and sold in markets. These marketed natural assets are either processed into products (such as gasoline or lumber) or are consumed directly (such as vegetables, fish, or beef). These marketed assets are standardized as commodities and measured by defined units, such as barrels of oil, cubic feet of gas, tons of coal, ounces of gold, board feet of timber, tons of wood pulp, pounds of fish, or bushels of oats.

The value of each of these standardized commodities is determined by the market price per unit of commodity. The market price is determined simultaneously by the both the cost of extracting or harvesting (called the cost of supply) and the amount that buyers are willing to pay (called demand). The total market value of a commodity is the product of the price per unit times the total number of units sold. Figure 7 shows the total market value of each major commodity derived from Alaskan natural assets.

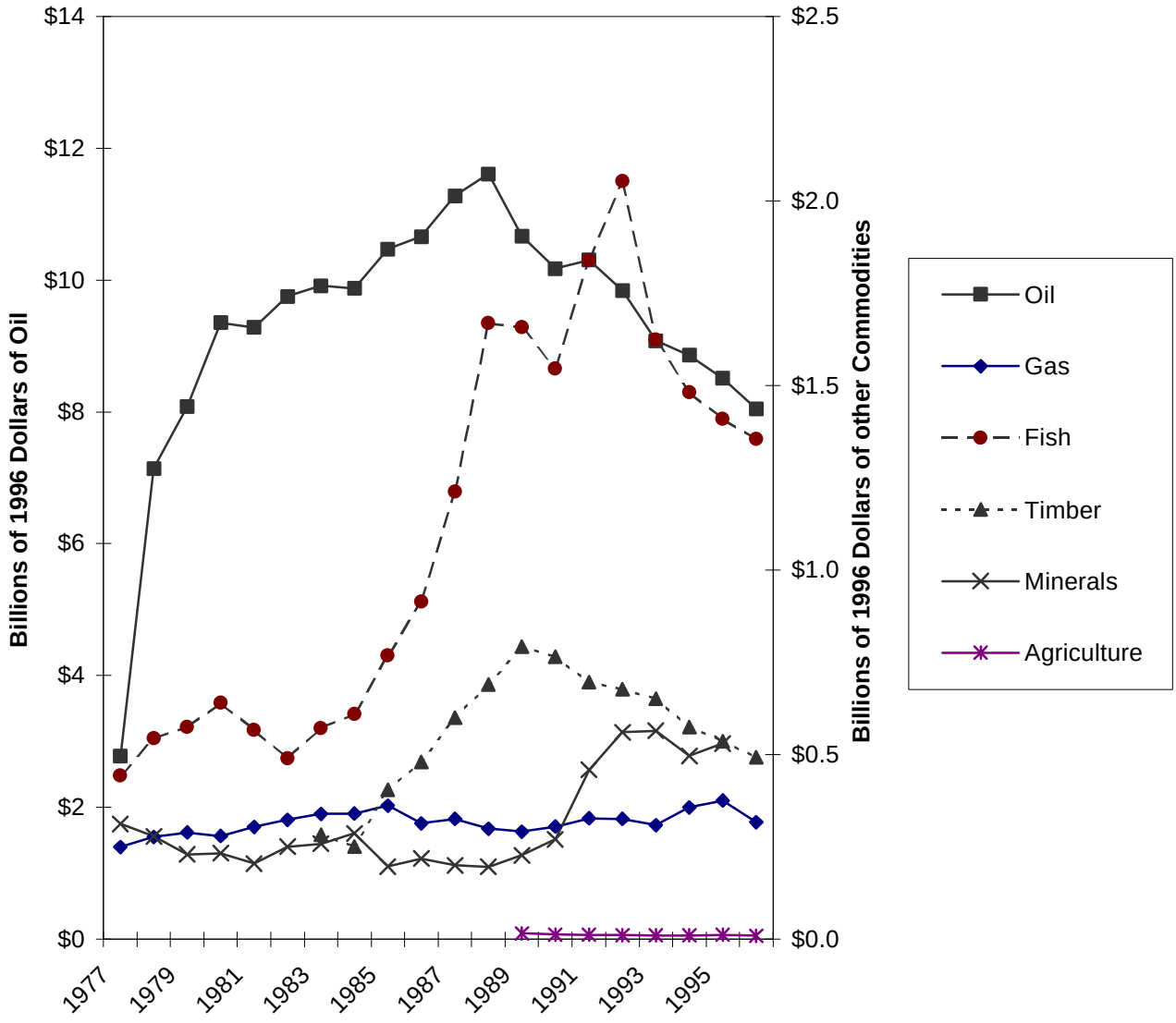
The market value of oil is by far the largest among all Alaskan commodities and has totaled more than $8 billion annually during the 1980's and early 1990's. The total market value of oil has declined recently as less oil is produced in the North Slope. The market value of fish

amounts to about $1.5 billion annually and varies considerably year to year due to variations in fish runs and world fish prices. The market value of timber products totals about $500 million annually; the market value of minerals amounts to $500 million each year; and the market value of natural gas amounts to about $300 million annually.

It is important to note that market value of these commodities includes the value of capital, labor, supplies, materials, and equipment used to extract or harvest the resource. For example, the cost of oil wells, pipelines, and oil industry workers' wages are included in the market value of oil. Similarly, the costs of wages for loggers, building logging camps, and cutting the logs are included in the market value of timber. The cost of fishing boats, crew shares, fishing gear, and fuel are included in the market value of fish.

The value of the raw natural resource *alone* is equal to the total market value of the commodity *minus* the dollar value of the contribution of workers, owners, capital, materials, supplies, and equipment used when extracting the resource. The remaining value is the contribution from the raw natural resource such as oil, timber, or fish. This contribution is called the "rental" cost or "economic rent" of oil, forest, fish, land, or any other natural resource that is used to make marketed commodities. There is currently no systematic effort to calculate these economic rents for each natural resource in Alaska. However, these estimates would be very useful to policy makers who need to evaluate how much we are being compensated for our raw natural resources.

FIGURE 7: Market Value of Natural Resources in Alaska in Billions of1996 Dollars



Sources: ISER estimates derived from Oil and Gas Commission, *Historical and Projected Oil and Gas Consumption* (1998), Bundtzen et al. *Alaska's Mineral Industry,* (1995), Hill, A. et al. *Timber Harvest and Wood Products Manufacture in Alaska,* (1996) , Alaska Department of Fish and Game, Commercial Fisheries Division, Alaska Agricultural Statistics Service, *Alaska Agricultural Statistics 1997* ,

B. Consumptive Use Value

1. Measuring Non-market Values

Many components of our natural assets are not traded in markets. Much of our wildlife, our wildlife habitat areas, national parks, refuges, and oceans are publicly owned and currently cannot be bought or sold in the market. Because the assets are not traded in the market, there is no readily available market price we can use to value the asset. We need to look for alternative methods to value these assets.

There are several well-developed techniques for evaluating the non-market value of natural resources and the environment. They are based on the idea of "willingness to pay," which is the amount buyers would be willing to pay if a market for the natural asset did exist. One way of measuring the willingness to pay is called "contingent valuation" method. After inventing and describing a hypothetical (contingent) market for some natural asset, the method surveys people to ask how much they would be willing to pay for particular natural assets in the hypothetical, or contingent, market.

There are several limitations to the contingent valuation method. It works well for valuing natural assets that can be easily defined or described to potential buyers; but it is often difficult for potential buyers to come up with estimates of their willingness to pay for whole ecosystems, broad areas, or large collections of natural assets. Sometimes respondents find the questions confusing since they think in general terms about how much they would spend on the environment rather than how much they would pay for a specific natural asset. Because the questions in a contingent valuation survey are about a *hypothetical* market, it is not based on actual behavior, but rather people's best guess at how they would behave if the were actually given these choices.[25]

An alternative method, called the travel cost method, is designed to improve on the contingent valuation method by relying on observations of the actual behavior (or revealed preferences) of consumers. The travel cost method attempts to measure the actual amount that consumers spend in getting to and using a natural asset. Consumers' spending is measured by surveying or observing their behavior and expenditures when they use or visit natural assets. The travel cost method is appropriate for measuring values associated with the *use* of natural assets; but it is not useful in estimating non-use values of assets that will be discussed in section III.D of this report.

2. Sports Hunting and Fishing

Contingent valuation and travel cost methods are most commonly used in studies of the economic value of sports hunting and fishing. These studies typically estimate the "net economic value" of hunting or fishing trips. The net economic value is the amount the hunter or fisher is willing to pay for a hunting or fishing trip minus the costs that they incurred to travel and to equip themselves for the trip. Estimates of net economic value are based on a surveys of individuals who have actually gone fishing or hunting and able to report how much the spent on the trip and how much they valued the trip. Notably, net economic value is the value placed on

the recreational experience of sportshunting or sportsfishing and is not necessarily the value of just the animal or fish that is caught or killed. Estimates of the net economic value of hunting and fishing trips are most appropriately applied to valuing particular sites or areas where there is detailed information available about the number of trips and type of fish or game available.

Several recent studies have estimated the net economic value of sport fishing and sport hunting in Alaska.[26] As listed in Tables 17 and 18, the net economic value that Alaskan resident hunters in 1994 attributed to overnight wildlife hunting trips was about $100 to $200 per trip, depending on what animal they targeted or bagged. Non-resident hunters in 1994 attributed a higher net economic value of $200 to $800 per trip for most species and as much as $1,200 for a wolf hunting trip. In 1997, resident sport fishers reported a net economic value for fishing trips that averaged about $123 per trip; but there was wide variation by region. Non–resident sport fishers valued trips more highly at $652 per trip.

For more information about methods for estimating economic value of non-market natural assets,

- *The Handbook of Environmental Economics*, edited by Daniel W. Bromley, Blackwell Publishers, Limited, 1995.

- *Economic Valuation of Natural Resources: Issues, Theory, and Applications*, edited by Rebecca L. Johnson and Gary V. Johnson, Westview Press, 1990.

- *Economics of the Wilds: Wildlife Diversity, and Development,* edited by Timothy Swanson and Edward Barbier, Island Press, 1992.

Table 17: Average Net Economic Value of Overnight Hunting Trips in Alaska for Residents and Non-Resident Hunters for each type of Species Targeted or Bagged in 1994 Dollars

Animal	Non-Residents		Alaska Residents	
	Targeted Species	Bagged Species	Targeted Species	Bagged Species
Black Bear	$366	$618	$152	$165
Brown Bear	$606	$751	$208	$86
Caribou	$432	$472	$168	$188
Moose	$393	$508	$181	$262
Wolf	$351	$1,230	NA	NA
Sheep	$492	$662	$267	$207
Goat	$419	$540	$126	$132
Deer	$222	$344	$143	$143
Elk	$88	NA	$99	$86
Waterfowl	$473	$262	$100	$145

Sources:
McCollum, D.W. and S.M. Miller. *Alaska Hunters: Their Hunting Trip Characteristics and Economics.* Alaska Department of Fish and Game, Anchorage, August 1994.
McCollum, D.W. and S.M. Miller. *Alaska Voters: Their Wildlife Related Trip Characteristics and Economics.* Alaska Department of Fish and Game, Anchorage, August 1994.
McCollum, D.W. and S.M. Miller. *Nonresident Hunters: Their Hunting Trip Characteristics and Economics.* Alaska Department of Fish and Game, Anchorage, August 1994.

Table 18: Average Net Economic Value of Sportfishing Trips in Alaska for Residents and Non-Residents to Different Regions in 1997 Dollars

Region	Alaska Residents			Non-Residents		
	Low	Mean	High	Low	Mean	High
Southeast	$29	$68	$119	$175	$381	$807
Southcentral	$32	$133	$243	$693	$797	$985
Southwest	$170	$240	$916	$759	$916	$906
Statewide	Not Available	$123	Not Available	Not Available	$652	Not Available

Source:
Haley, S., S. Goldsmith, A. Hill, M. Berman, and H. Kim. *Review Draft: The Economics of Sport Fishing in Alaska.* Prepared for Alaska Department of Fish and Game, Institute of Social and Economic Research, University of Alaska Anchorage, September 1997.

3. Subsistence Use

Subsistence use of natural assets includes hunting, gathering, and harvest of fish, animals, and plants for personal use that is neither commercial nor recreational. More broadly, subsistence includes processing animals and plants into food, clothing, and other products. Subsistence use also includes activities such as care of dog teams, repairing fish wheels, building salmon drying racks, the maintenance of snow machines and boats, and other associated activities that are necessary for harvesting and processing subsistence foods and products. The subsistence lifestyle is an integral part of community activities in many Alaska villages and is integrated into potlatches, traditional rituals, and cultural identity. The subsistence lifestyle for many Alaska Natives it is central to their culture and way of life and is a choice for some non-Native Alaskans.[27]

While it is possible to measure the value of consumptive recreational users like sports hunting and fishing, the usual methods do not work when applied to subsistence use, particularly for Alaska Natives. One method for measuring the value of subsistence is to ask subsistence participants how much they are willing to pay to engage in subsistence. However, many Alaska Natives consider subsistence to be a right or a way of life, and they consider such questions irrelevant or inappropriate.

As an alternative, the travel cost method could estimate the value of subsistence by observing how much time and effort people spend to harvest subsistence foods. Some travel cost studies have attempted to estimate the value of subsistence by placing a dollar value on the amount of time spent harvesting and gathering subsistence foods and products.[28] These studies are most appropriate for valuing subsistence activities in a particular village or area where there is detailed information available about what subsistence methods are used, what jobs are available, and how people use their time.

However, the practical difficulty of observing and measuring the amount of time, effort, and resources make this type of measurement difficult. Even when detailed information is available, it is hard to separate the time spent on subsistence activity from other everyday activities because hunting, harvesting, gathering, processing, and sharing subsistence harvests are intricately interwoven into the lives of Alaska Natives.

The nutritional value of harvested wild plants and animals is a more practical and meaningful way to measure the value of subsistence.[29] The nutritional value of subsistence harvested is estimated by comparing the caloric and protein content of subsistence foods to the average daily nutritional requirements for protein and calories. Subsistence harvest is considered more valuable if it provides a higher percentage of daily protein and caloric requirements. As listed in Table 17 below, wild subsistence harvest foods fill more than twice the protein requirements of rural subsistence users and about one third of their total caloric requirements. Urban subsistence users receive a smaller percentage of the nutritional requirements from wild harvest.

The replacement cost method is another way to measure the value of subsistence harvests. This method approximates the price of subsistence foods by finding comparable foods

in grocery stores. [30] The price of the comparable grocery food is used as a proxy for the price of subsistence foods. This method produces an underestimate of total value of subsistence because it does not include the value associated with the activity of subsistence hunting, gathering, and harvesting itself. In addition, there are practical difficulties in determining the replacement cost of some subsistence foods that are not easily compared to foods found in grocery stores.

Table 19: Annual Nutritional Value and Replacement Value of Subsistence Wild Resource Harvests in Alaska during the 1990's

	Percent of Daily Nutritional Requirements Fulfilled by Wild Harvest		Replacement Value of Wild Harvest in Millions of 1996 Dollars	
Region	**Percent of Protein Requirements Fulfilled**	**Percent of Calorie Requirements Fulfilled**	**at $3 per pound**	**at $5 per pound**
Rural	243%	35%	$131.1	$218.6
Urban	13%	2%	$29.2	$48.7
Statewide	63%	9%	$160.4	$267.3

Source: Robert J. Wolf, "Subsistence Food Harvests in Rural Alaska and Food Safety Issues," paper presented to the Institute of Medicine, National Academy of Sciences Committee on Environmental Justice, Spokane Washington, August 13, 1996, available online at http://www.state.ak.us/local/akpages/FISH.GAME/subsist/subsist/download/food962.pdf

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The Alaska Department of Fish and Game, Subsistence Division has two summary reports about subsistence harvests and the value of subsistence:

- Robert J. Wolf, "Subsistence Food Harvests in Rural Alaska and Food Safety Issues," paper presented to the Institute of Medicine, National Academy of Sciences Committee on Environmental Justice, Spokane Washington, August 13, 1996, available online at http://www.state.ak.us/local/akpages/FISH.GAME/subsist/subsist/download/food962.pdf

- Division of Subsistence, Alaska Department of Fish and Game, *Subsistence in Alaska: 1994 Update*, March 1, 1994, available online at http://www.state.ak.us/local/akpages/FISH.GAME/subsist/subsist/download/subupd94.pdf

C. Non-Consumptive Use Value

Non-consumptive uses of nature leave natural assets intact without depleting or consuming them. These non-consumptive uses include recreational activities such as hiking, photography, wildlife viewing, and skiing. In addition, the foundation of the tourism industry in Alaska is the non-consumptive use and enjoyment of natural assets by tourists.

1. Outdoor Recreation

The Alaska Division State Parks and Recreation regularly conducts a survey of Alaskan residents to learn how many residents engage in different types of non-consumptive outdoor recreation activities.[31] The results of their most recent survey are listed in the Table 20. Notably, over two-thirds of all Alaskans picnic, ski, and drive for pleasure or sightseeing. Half of the state's residents go hiking, bicycling, or walking. Over a third of all Alaskans go bird watching, play in parks or playgrounds, go sledding, hike along trails, tent camp in campgrounds or in the backcountry. One quarter or more of Alaska residents jog or run outdoors, use powerboats and snowmachines, canoe, rafts, take float trips, or play outdoor court and field games.

There are currently no comprehensive estimates of the total economic value attributable to all of these recreational activities of Alaskans. However, several studies have tried to estimate the economic value of a few of these particular activities in particular areas.[32] A recent study by the Alaska Department of Fish and Game asked Alaskan residents their willingness to pay for wildlife viewing trips.[33] They estimate the net economic value of wildlife viewing trips as the total willingness to pay minus the costs incurred to go on the trip. Their results are presented in the Table 21. Depending on the type of wildlife sought or seen, survey respondents attributed a net economic value of $100 to $300 per wildlife viewing trip.

Table 20: Non-Consumptive Outdoor Recreation Activities of Alaskans

	Percent of Alaska Residents participating in each activity				Of those who Participate, the average number of times each year they participate
	Total	Within their community	Within one hour of their community	More than one hour away from their community	
Driving for Pleasure / Sightseeing	81%	15%	31%	35%	27
Picnicking	76%	33%	26%	17%	12
Hiking	66%	15%	30%	21%	15
Bicycling/ Mountain Biking	64%	49%	11%	4%	34
Walking for Fitness	61%	56%	3%	2%	50
Berry Picking	53%	21%	18%	13%	7
Bird Watching / Wildlife Viewing	49%	23%	17%	10%	29
Playgrounds/Open Space Activities	46%	41%	3%	2%	16
Sledding	46%	36%	8%	3%	12
Tent Camping in Campground	41%	3%	10%	28%	9
Skiing on Trails	34%	22%	9%	3%	18
Tent Camping in Backcountry	33%	2%	5%	26%	9
Outside Court Games	32%	31%	1%	1%	14
Field Games	30%	28%	2%	1%	26
Jogging / Running	29%	41%	3%	2%	47
Powerboating	28%	5%	9%	14%	17
Snowmachining	26%	10%	8%	8%	28
River Canoeing / Rafting / Floating	26%	5%	6%	15%	9
RV Camping	24%	1%	4%	19%	13
Swimming	24%	14%	5%	5%	16
ORV / ATV riding	24%	8%	9%	7%	26
Outdoor Ice Skating / Ice Hockey	22%	18%	2%	1%	11
Golf	15%	12%	2%	1%	15
Skiing Backcountry	12%	2%	4%	6%	15
Horseback Riding	10%	3%	3%	3%	17
Rockclimbing / Ice climbing	8%	1%	5%	2%	9
Dog Mushing / Ski joring	8%	5%	2%	0%	23
Motocross	6%	2%	3%	1%	32
Sailing / Windsurfing	5%	1%	2%	2%	8
Sea Kayaking	5%	1%	1%	3%	8

Source: Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, Alaska's Outdoor Legacy, Statewide Comprehensive Outdoor Recreation Plan, 1992-1996, September 1993.

Table 21: Average Net Economic Value of Wildlife Viewing Trips in Alaska for Each Type of Wildlife Sought or Seen in $1994

Wildlife Sought or Seen	Average Value of trip for each type of wildlife sought	Average Value of trip for each type of wildlife seen
Any Bears	$274	$170
Grizzly Bears	$274	$226
Caribou	$126	$135
Moose	$101	$123
Wolf	$143	$195
Sheep	$180	$132
Mountain Goat	$305	$206
Whales	$160	$152
Sea Birds	$169	$130
Eagles	$163	$147

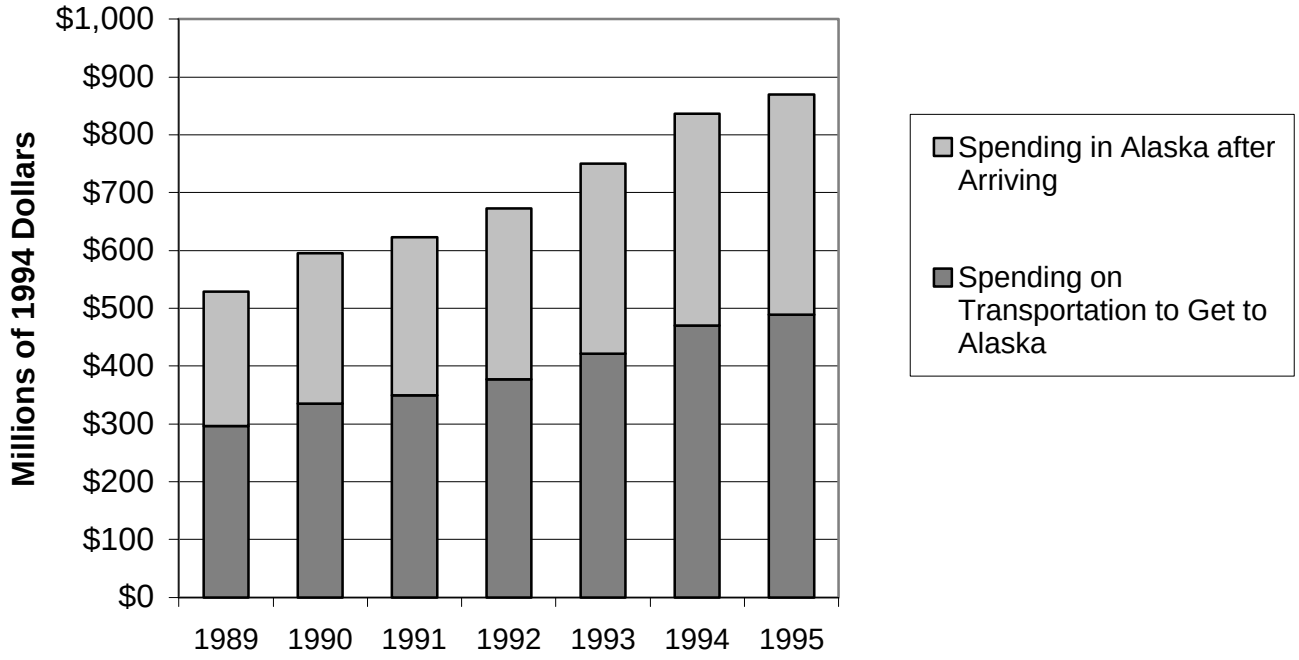
Source: McCullom and Miller et al., *Alaska Voters, Hunters, and Non-Resident Hunters, Their Wildlife Related Trip Characteristics and Economics*, prepared for Alaska Department of Fish and Game, November 1994.

2. Tourism

The tourism industry in Alaska relies on nature to provide the aesthetic natural beauty, open spaces, wildlife, and other natural wonders that tourists come to Alaska to see and experience. As listed in the Table 22, most of the top ten tourist attractions in Alaska are natural attractions. There is no definitive measure of the value that tourists attribute to the value of Alaska's natural assets. However, the total expenditures by tourists on their trips to Alaska can serve as one general indicator of how much they are willing to pay to enjoy the natural assets of Alaska. It is important to keep in mind that tourists do more than enjoy natural assets on their trip, so tourist expenditures are *not* an accurate measure of the economic value of the natural assets. As shown in Figure 8, the amount that tourists spend on both transportation to get to Alaska and the amount they spend instate totals over eight hundred million dollars annually and has increased steadily over the past decade.

Table 22: Top Tourist Attractions in Alaska		
Attraction	Number of Visitors in 1995	Percent of all visitors visiting attraction in 1995
Inside Passage	387,200	46%
Portage Glacier	370,000	44%
Ketchikan Totems	331,800	38%
Mendenhall Glacier	331,800	38%
Denali National Park	301,200	34%
Skagway's Historic Gold Rush District	296,700	34%
Glacier Bay National Park	256,400	35%
Anchorage Museum of History and Art	216,300	29%
Sitka's Russian Church and Dancers	186,000	20%
Source: Alaska Department of Commerce and Economic Development, Division of Tourism, Alaska Visitors Statistics Program, and Alaska Almanac, Facts about Alaska, 1996.		

FIGURE 8: Total Spending by Tourists for Travel to Alaska and Spending in Alaska in millions of 1994 dollars



Source; Alaska Visitor Statistics Program, Visitor Expenditure Surveys for estimates of instate spending.
ISER estimates of spending on travel to get to Alaska

D. Non-Use Value

1. Defining Non-Use Value

So far, we have focused on the value natural assets for consumptive and non-consumptive uses -- all associated with *using* assets in some way. However, there are many benefits from nature not associated with using them. There is no definitive list of these "non-use" benefits from nature because not everyone holds the same values for nature. However, environmental ethicists have developed categories of values that nature holds or carries for various groups of people. While not everyone may hold each of these values for nature, members of our society have identified the values listed below as part of an environmental ethic that they rely on to make choices.[34]

Option Value: Even if they never visit open spaces for recreation or tourism, many people still value the option or opportunity to visit these natural assets in the future. Many potential tourists, for example, have never visited Denali National Park, yet they value the option to visit the park in the future. Similarly, some Alaska residents who have never visited open areas of the state value having these areas available for recreational use in the future.

Bequest Value: Even if they never have the opportunity to visit nature wonders themselves, many people value preserving natural wonders so future generations can enjoy them. For example, many value the preservation of national parks and monuments, wild scenic rivers, or rare animal species so that their children will be able to experience them. Being able to bequest some aspects of our natural assets to our children is valuable for some people because it ensures that their children will have the same opportunities they've had.

Aesthetic Value: The appreciation of beauty is subjective, hard to put in words, and even harder to value in dollars. Aesthetic value is an appreciation of the unique, the grace, the grandeur, the color, the "specialness," and the awe of nature. Tourists, Alaskan residents, and people who may never come to Alaska appreciate and value the aesthetic beauty of wildlife, forests, and open spaces in Alaska.

Scientific and Education Value: Nature provides a storehouse of information about the origins of our world, how we evolved, and where we came from. Through scientific research and education, we can learn about the laws of nature and how the world works. This knowledge is valuable addition to our understanding of our place within nature.

Historical Value: Americans have a history of self-development forged in a struggle against a diverse and challenging natural environment. Alaska is called the Last Frontier because of a long historical tradition of taking risks in the natural environment and venturing deeper and deeper into nature. Nature provides us with an historical record of these discoveries, struggles, and achievements of our ancestors and reminds us what was necessary to bring us to where we are in the present.

Cultural Symbolism Value: The American bald eagle is a symbol of freedom and strength emblazoned on our currency and presidential seal. The mountain, Denali, is conjured by

poets, artists, and writers as a symbol of Alaskan majesty and greatness. Alaskan wilderness has become symbolic of wild, untouched nature for some urban dwellers who value knowing that unsettled areas still exist. Particular endangered species have become symbols of the last remaining parts of nature that have not yet been developed. These symbolic values of nature are often emotional and controversial; and yet for some people, these symbolic values are the primary motivation for creating a personal environmental ethic.

Character Building Value: Whether people go out camping with the boy scouts, attend an outward bound training session, or learn backcountry travel skills, nature often provides the backdrop and the challenge for motivating them to develop and to become more of who they are. The risky, unknown, and unpredictable aspects of nature challenges individuals learn how to assess dangers and take informed risks as an individual or as a group. This training in risk management enables them to assess and to evaluate risks in other parts of their lives even when they are in an urban setting.

Stability and Spontaneity Value: Nature offers stability in the form of regular cycles of night and day, predictable seasons of the year, constant gravity, and reliable patterns of growth and decay. This stability and predictability is a valuable foundation that enables humans to settle, to form communities and civilizations, and to coordinate activities. At the same time, nature also offers perpetual uniqueness and spontaneity – every snowflake, leaf, cloud, and animal is unique and different. This abundant novelty and newness of nature spurs us to create, to invent, to be spontaneous, and to look for the new, unique, and different.

Dialectical Value: We are engaged with a constant dialectic struggle within and against nature. Our bodies and all of our internal physiological processes are part of nature. We are animals who evolved from other animals through the course of natural selection within the ecosystem. Yet at the same time, we endeavor to carve out our existence apart and separate from nature: we struggle to tame nature, to be civilized and separate from animals, and to ensure our survival against the potentially destructive aspects of nature. Our success as a species with this dialectic struggle to simultaneously be part of nature and separate from nature ensures that our species survives, evolves, and further defines our ethical relationship with nature.

Life Value: Reverence for all forms of life is commended by every great religion. Those who are not religious will find in our literature, art, and culture abundant examples of the respect for life. The first lesson humans learned in evolution may have been one of conflict – that we need to ensure the survival of our own species and that all other life forms exist to contribute to human life. But as we have evolved, we learned that we share a kinship with all other life: they are born of the same earth, made from the same biological building blocks, and share the same genetic basis for life. This kinship encourages us to value animals, forests, plants, and other life -- simply because they are alive.

Religious Value: Reverence for nature permeates our poetry, art, philosophy, religion and culture. Nature's most profound educational value comes when we are captivated by the grandeur of a starry night, humbled by the ferocity of a stormy surf, spellbound by a beautiful canyon vista, seduced by the mystery of life, or uplifted by the heights of a mountain top. These and other inspiring experiences have left people with indelible insights that enlighten them to a

greater awareness of their own existence. Alaska Natives have integrated these spiritual experiences into their lifestyles and culture with stories and myths that vividly describe the awe and mystery of nature.

2. Measuring Non-Use Values

Many of these non-use values cannot be meaningfully measured in numbers or dollars. Non-use values are more appropriately expressed in literature, art, lifestyles, or other aspects of our culture. Putting monetary values on many of these non-use values diminishes them and provides an inaccurate portrayal of how they are valued or cherished by people. Quantitative measures such as the number of dollars are best used to describe the relative size or magnitude of values. This numerical approach cannot always convey other equally important characteristics of non-use values such as their duration, intensity, or emotional content. Furthermore, monetary measures cannot fully convey the cultural impacts, the effects on future generations, the contributions to communities, or the improvement in individuals' quality of life that non-use values provide.

Despite these limitations, many public policy decisions about the use or conservation of natural assets require that we somehow compare non-use values of nature with the monetary value of using natural assets. Since non-use values cannot be adequately expressed in numbers, they are often put on an unequal footing in public debate when they are compared to consumptive use values that are more readily measured in dollars. In order to provide non-use values a more equitable footing in public debate about the use or conservation of natural assets, several economic methods have been developed to attempt to place a dollar value on selected non-use values of nature.[35] These economic methods provide one perspective on non-use values; they are neither a definitive nor complete characterization of non-use values.

Economic methods attempt to measure the value attributed to the "option," "bequest," and “existence” value of selected natural assets. As described above, "option" and "bequest" values refer to the value of using natural assets in the future or leaving them for future generations to use. “Existence value” is a term used to collectively describe many different non-use values of nature.[36] It is the value that people hold for the “existence” of some aspect of nature -- even if they never use or see that part of nature now or in the future. Existence value is likely different for every individual and embodies some or all of the non-use values listed above. One way to measure "option," "bequest," and “existence" values in monetary terms is to ask individuals how much they would be willing to pay for a particular natural asset even if they have never used, visited, or seen it.

a. Preservation of Endangered Species

These sorts of monetary measures of existence value have been used to estimate the economic value of preserving endangered species. These studies typically survey households to ask how much they would be willing to pay to preserve an endangered species or its habitat. The results of some of these studies are listed in the Table 23.[37] The estimates of the value of preserving these selected endangered species range anywhere from $20 to almost $100 per household for various preservation or habitat protection proposals. The total value of the

preservation is estimated by multiplying the willingness to pay per household, individual, or respondent by the total number of households in the region. It is important to note that these studies are specific to particular areas and species; the results are highly sensitive to the phrasing of the question; and it is often hard for respondents to distinguish the their willingness to pay for a particular species from their willingness to pay for preserving the habitat required to maintain those species.

b. Preservation of Wilderness and Open Space

Other studies have tried to assess the willingness to pay for the preservation of wilderness. The results from a selection of these studies are listed in Table 24.[38] These studies typically ask a sample of either households or individuals in a study region how much they would be willing to pay for the preservation of a particular wilderness area. Depending on the wilderness area to be preserved, the studies estimate average willingness to pay ranging from $10 to $50 dollars per household or individual. To find the total value of preserving the wilderness area, the studies multiply the willingness to pay per household by the total number of households or individuals in the study region.

Two particular studies listed in Table 24 focused on the value of preserving open spaces in Alaska. After the Exxon Valdez oil spill, one study surveyed a sample of households in the United States to ask how much they would be willing to pay for a spill prevention plan that would prevent another comparable spill and avoid damage to the Prince William Sound ecosystem. This study found a willingness to pay of about $31 per household for a spill prevention plan. When multiplied by the total number of households in the United States, the total value of preventing a spill in the Prince William Sound area was valued by Americans at several billion dollars.[39]

A more recent study looked at the willingness to pay for preserving wilderness in three wildlife refuges in the Bristol Bay area of Alaska. [40] This study did not conduct its own survey but instead relied on estimates from studies of the willingness to pay for wilderness preservation in comparable areas. The Bristol Bay study placed the willingness to pay for wildlife refuge preservation at somewhere between $25 and $50 dollars per household in the U.S. When this estimate is scaled up to all U.S. households, the study found that the amount Americans would be willing to pay to preserve wilderness in the Bristol Bay wildlife refuges amounts to several billion dollars annually.

Table 23: Summary of Willingness to Pay for Rare and Endangered Species

Authors (Date)	Study Location	Description of Resource	Willingness to Pay[1] ($1997)	Comments on Non-Use Value Components
Brookshire, et al. (1983)	Wyoming	Restore (a) grizzly bear and (b) bighorn sheep populations in 5 years	(a) $36.87; (b) $11.37 per resident	Exclusively existence
Hageman (1985)	California	Avoid loss of (a) blue and gray whale, (b) bottlenose dolphin, (c) California sea otter, and (d) northern elephant seal populations	(a) $33.96; (b) $24.21; (c) $27.14; (d) $26.15 per resident	
Boyle and Bishop (1987)	Wisconsin	Avoid loss of bald eagle population	$14.37 to $41.65 per household[2]	Total value allocated between non-consumptive use (e.g., viewing opportunities), option for future use, existence; estimate range excludes non-consumptive use.
Duffield (1991)	Yellowstone NP, California	Restore northern Rocky Mountain wolf population to maintain presence in Yellowstone	$13.81 per visitor	
Loomis and Larson (1992)	California	Increase gray whale populations (50%)	$18.19 per household	
Walsh, et al. (1987)	Colorado	Wildlife protection programs (enhance current conditions)[3]	$62.99 per household	Total value allocated between recreation, option, existence, bequest; this estimate excludes recreation
Adamowicz, et al. (1991)	Alberta, Canada	Wildlife management and preservation program (restrict access and improve habitat to prevent population decline)	$95.55 per household	

Notes:
[1] All estimates represent annual willingness to pay values, except for Duffield (1991) which reports a lump sum payment.
[2] Range based on whether or not respondent was currently a contributor to an existing Wisconsin natural resources donation program.
[3] Resident wildlife includes 26 threatened or endangered species such as the bald eagle, peregrine falcon and river otter.

Source: Oliver Scott Goldsmith, Alexandra Hill, and Teresa Hull, *with* Industrial Economics, Incorporated, *Economic Impact Assessment of Bristol Bay Area National Wildlife Refuges,* prepared *for* U.S. Fish and Wildlife Service, Institute of Social and Economic Research, 1998.

Table 24: Summary of Willingness to Pay for Wilderness Preservation

Author (Date)	Study Location	Description of Resource	Description of Commodity	Annual Willingness to Pay (1997$)
Carson et al. (1992)	Alaska: Prince William Sound	Prince William Sound coast and waters	WTP for spill prevention plan[5]	$31 per household (1992$)
Goldsmith and Hill (1998)	Alaska: Bristol Bay Wildlife Refuges	13.2 million acre wildlife refuges made up of three separate refuges	WTP for preserving wildlife habitat[6]	$25 to $50 per household
Walsh, et al. (1984)	Colorado	1.2 million acre designated wilderness area (2% of total state acreage) made up of 13 separate areas.	WTP to preserve current wilderness areas[1]	$25.90 per household
Bishop and Boyle (1985)	Illinois	Illinois Beach State Nature Preserve; 830 acres of dune habitat; only record of geologic history of Lake Michigan	WTP to ensure maintenance and/or protection of the nature preserve[2]	$32.97 per resident
Gilbert, A., et al. (1991)	Vermont	Lye Brook Wilderness Area, Green Mountain National Forest	WTP for protection, continued management of the area[3]	$10.38 per person
Gilbert, L. (1994)	Massachusetts	Parker River National Wildlife Refuge; 4,662 acres, six miles of barrier beach	WTP to ensure maintenance and/or protection of the Refuge[4]	$26.78 per visitor

Notes:
[1] Respondents were Colorado Residents; does not include recreational use.
[2] Respondents were Illinois residents who had not visited the Preserve during the study period.
[3] Respondents were Vermont, New York, Massachusetts or New Hampshire residents within a 75-mile radius of the Green Mountain National Forest who had never visited an Eastern wilderness area.
[4] Respondents were refuge visitors, 77 percent of which were Massachusetts's residents.
[5] Respondents were households throughout the United States
[6] Based on average WTP in comparable areas

Source: Oliver Scott Goldsmith, Alexandra Hill, and Teresa Hull, *with* Industrial Economics, Incorporated, Economic Impact Assessment of Bristol Bay Area National Wildlife Refuges, prepared *for* U.S. Fish and Wildlife Service, Institute of Social and Economic Research, 1998

E. Value of Life Support Services

We have looked at methods for valuing many separate natural assets. Most of these valuation methods are designed to measure particular uses or assets and are not usually applied to whole ecosystems. Because there is such variation from one region to another and from one natural asset to another, it is often necessary to look at each asset individually to arrive at estimates of its value.

However, one recent study by ecological economist Robert Costanza and his associates attempted to estimate the total value of all life support services provided by the entire global ecosystem.[41] This comprehensive study collected estimates of the willingness to pay for many different life-support services from a variety of other studies. Using these collected results, the study developed estimates of the dollar value per hectare of each type of life support service provided by nature. The results of their survey are shown in Table 25 on the following pages.

The aim of their study was to estimate the total dollar value of all life support services provided each year by the global ecosystem. So, they scaled their estimates of the value per hectare to the total value for all hectares in the global ecosystem. They found that the annual dollar value of life support services provided by the global ecosystem is two to five times larger than the annual output (gross product) of the global economy. When their estimates of value per hectare are applied to Alaska, the value of life-support services provided by natural assets in Alaska amounts to roughly ten to twenty times more than the annual output (gross state product) of the state economy.[42]

Since the total value of services provided by the ecosystem is substantially larger than the size of the economy, it is not clear how to interpret these values. Critics of this approach argue that it is not meaningful to have a dollar value larger than the total output of the global economy because the transaction could never take place – no one has enough money to pay for the transaction. Other critics argue that ecological processes cannot be meaningfully quantified or valued in dollars. There is an ongoing debate between ecologists and economists about the appropriate interpretation and applicability of these results.[43]

Their estimates do, however, provide some indication of the average magnitude of the value of life support services provided by a hectare of land or marine environment. For example, wetlands provide highly valuable life support services such as regulating disturbances to the ecosystem, storing water, and treating wastes. The value of these services amounts to as much as $14,800 per hectare per year. Lakes provide valuable services such as water storage and regulation that amount to over $8,000 per hectare per year. Coastal marine areas provide valuable food production services, nutrient cycling, and recreation opportunities that average more than $4,000 per hectare per year. Forests and grasslands provide climate regulation, recreation, waste treatment, habitat, food production and other life support services that amount to $200 to $300 annually.

Table 25: Average Annual Value of Ecosystem Life Support Services per Hectare (1994 U.S. Dollars per Hectare per Year)

Life Support Service	Terrestrial								
	Temper-ate & Boreal Forest	Grass and range land	Wet lands	Lakes/ Rivers	Desert	Tundra	Ice/rock	Crop land	Urban
Gas regulation		$7	$133						
Climate regulation	$88	$0							
Disturbance regulation	$2		$4,539						
Water regulation		$3	$15	$5,445					
Water supply			$3,800	$2,117					
Erosion control and sediment retention		$29							
Soil formation	$10	$1							
Nutrient cycling									
Waste treatment	$87	$87	$4,177	$665					
Pollination		$25						$14	
Biological control	$4	$23						$24	
Habitat			$304						
Food production	$50	$67	$256	$41				$54	
Raw materials	$25		$106						
Genetic Resources		$0							
Recreation	$36	$2	$574	$230					
Cultural	$2		$881						
Total Value per Hectare per year	$302	$232	$14,785	$8,498	$92				

Table 25 Continued: Average Annual Value of Ecosystem Life Support Services (In 1994 U.S. Dollars per Hectare per Year)

Life Support Service	Marine						Total
	Open Ocean	Coastal					
		All Coastal Combined	Estuaries	Seagrass / Algae	Coral Reefs	Shelf	
Gas regulation	$38						$1,341
Climate regulation							$684
Disturbance regulation		$88	$567		$2,750		$1,779
Water regulation							$1,115
Water supply							$1,692
Erosion control and sediment retention							$576
Soil formation							$53
Nutrient cycling	$118	$3,677	$21,100	$19,002		$1,431	$17,075
Waste treatment					$58		$2,277
Pollination							$117
Biological control	$5	$38	$78		$5	$39	$417
Habitat		$8	$131		$7		$124
Food production	$15	$93	$521		$220	$68	$1,386
Raw materials		$4	$25	$2	$27	$2	$721
Genetic Resources							$79
Recreation		$82	$381		$3,008		$815
Cultural	$76	$62	$29		$1	$70	$3,015
Total Value per Hectare per year	$252	$4,052	$22,832	$19,004	$6,075	$1,610	

Source: Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and J. van den Belt. "The Value of the World's Ecosystem Services and Natural Capital," *Nature*.15 May 1997. http://www.america.nature.com/ (April 1998).

IV. Conclusions

The people of Alaska and our economy rely on nature for a broad range of resources, services, and benefits. We depend on nature for breathable clean air, drinkable water, and safe food. We extract raw materials that we use for energy, sell as commodities to earn income, and manufacture into products. We enjoy outdoor recreation activities and rely on Alaska's natural attractions as a foundation for the tourism industry. Members of our society also value nature for many other cultural, educational, and non-use benefits.

As we make choices about how to use and to conserve our natural assets, we must be willing to consider *all* of these many different values for nature. Some of these values can easily be quantified in dollar terms. Other values are more elusive and difficult to quantify. To accurately compare and assess the full range of values for nature, we must be willing to consider values that are not quantifiable in dollars but are instead expressed in our literature, art, communities, and culture.

Endnotes

[1] For more information about the full range and variety of benefits from nature, see *The Value of the World's Ecosystem Services and Natural Capital,* by Robert Costanza, Ralph d'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton, and Marjan Van Den Belt, in *Nature,* Vol. 387, No. 15 (May 1997), p 254.

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[11] These "existence values" are described in more detail in "Section III.D: Non-Use Values" of this report.

[12] For more details about animal populations in particular game management units, see Alaska Department of Fish and Game, Wildlife Conservation Division, summary statistics on terrestrial mammal populations assembled from "Federal Aid in Wildlife Restoration Annual Performance Reports Survey-Inventory Activities," 1995.

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[15] Robert Wolfe, *Subsistence Food Harvests in Rural Alaska, and Food Safety Issues*, paper presented to the Institute of Medicine, National Academy of Sciences Committee on Environmental Justice, Spokane Washington.

[16] These "existence values" are described in more detail in "Section III.D: Non-Use Values" of this report.

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[35] One alternative to these inequitable comparisons is to recognize that size or magnitude is not the only thing that matters. We need a way to compare the quality, duration, intensity, and cultural and social qualities of our values for nature. This alternative is beyond the scope of this report and would require a discussion of environmental ethics, value, and public policy. Future research could investigate and document the various environmental ethics used to make decisions and justify actions in Alaska.

[36] Existence value is sometimes distinguished from option value and bequest value. While existence value is for non-use values in the *present*, option and bequest value are for non-use values in the future. When individuals are asked to distinguish these different values in surveys, they have a difficult time discerning whether the values they hold are for the present or future. For the purposes of this report, I include option and bequest value in the discussion of existence values in general.

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[42] Applying the results of Costanza et al. to Alaska is difficult since we do not have precise estimates of the acreage of each type of ecosystem resource for the state. In addition, the worldwide averages that Costanza estimates may not be applicable to all areas of Alaska.

[43] An extensive online critique and discussion of Robert Costanza's paper on the value of natural capital is available at http://csf.colorado.edu/sustainable-economics/search/ecovalue/. This online discussion of the Value of Natural Capital includes comments by Michael R. Bauer, Virginia Tech, "Values and Evaluation," Peter Bein, Ministry of British Columbia, "Measuring the Infinite in Policy and Project Appraisals," Klaus Rennings, Department of Environmental and Resource Economics, Centre for European Research, "Monetary Valuation and Sustainability Paradigms," Doug Hinrichs, "Environmental Valuation and Sustainability," and forthcoming author of "Reconciling Economy and Ecology: Valuation from the point of view of Sustainability." Colin Green, Middlesex Environmental Research Institute, "Nature Paper."

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[23] Leaking underground storage tanks are monitored under a separate program within ADEC.

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[35] One alternative to these inequitable comparisons is to recognize that size or magnitude is not the only thing that matters. We need a way to compare the quality, duration, intensity, and cultural and social qualities of our values for nature. This alternative is beyond the scope of this report and would require a discussion of environmental ethics, value, and public policy. Future research could investigate and document the various environmental ethics used to make decisions and justify actions in Alaska.

[36] Existence value is sometimes distinguished from option value and bequest value. While existence value is for non-use values in the *present*, option and bequest value are for non-use values in the future. When individuals are asked to distinguish these different values in surveys, they have a difficult time discerning whether the values they hold are for the present or future. For the purposes of this report, I include option and bequest value in the discussion of existence values in general.

[37] This table is adapted from Oliver Scott Goldsmith, Alexandra Hill, and Teresa Hull, *with* Industrial Economics Economic Impact Assessment o Bristol Bay Area National Wildlife Refuges: Alaska Peninsula, Becharof, Izembek, Togiak *Review Draft*, Delivery Order II-011, Contract #14-480009-95-005, *for* U.S. Fish and Wildlife Service *by*, Incorporated, Institute of Social and Economic Research, 1998.

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[41] Source: Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and J. van den Belt. "The Value of the World's Ecosystem Services and Natural Capital," Nature.15 May 1997. http://www.america.nature.com/ (April 1998).

[42] Applying the results of Costanza et al. to Alaska is difficult since we do not have precise estimates of the acreage of each type of ecosystem resource for the state. In addition, the worldwide averages that Costanza estimates may not be applicable to all areas of Alaska.

[43] An extensive online critique and discussion of Robert Costanza's paper on the value of natural capital is available at http://csf.colorado.edu/sustainable-economics/search/ecovalue/ This online discussion of the Value of Natural Capital includes comments by Michael R. Bauer, Virginia Tech, "Values and Evaluation," Peter Bein, Ministry of British Columbia, "Measuring the Infinite in Policy and Project Appraisals," Klaus Rennings, Department of Environmental and Resource Economics, Centre for European Research, "Monetary Valuation and Sustainability Paradigms," Doug Hinrichs, "Environmental Valuation and Sustainability," and forthcoming author of "Reconciling Economy and Ecology: Valuation from the point of view of Sustainability." Colin Green, Middlesex Environmental Research Institute, "Nature Paper."