ECOREGIONS/ASSESSMENT ENDPOINT PROJECT

TECHNICAL BACKGROUND DOCUMENT FOR SELECTION AND APPLICATION OF DEFAULT ASSESSMENT ENDPOINTS AND INDICATOR SPECIES IN ALASKAN ECOREGIONS

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (cont.)

LIST OF TABLES

Table No.

LIST OF FIGURES

Figure No.

LIST OF APPENDICES

Appendix

ABBREVIATIONS AND ACRONYMS

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADPH	Alaska Department of Public Health
ºC	degrees Centigrade
CCELC	Canada Committee on Ecological Land Classification
CCLBRR	Canadian Centre for Land and Biological Research
cm	centimeter
COPEC	contaminants of potential ecological concern
Corps	U.S. Army Corps of Engineers
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
km^2	square kilometers
m	meter
OIW	Oceanographic Institute of Washington
NA	not applicable or not available
Navy	U.S. Navy
NOAA	National Oceanic and Atmospheric Administration
RAWP	Risk Assessment Work Plan
USDOI	U.S. Department of the Interior
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

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Alaska Department of Environmental Conservation

Linda Himmelbauer	Project Manager
Bill Janes	Project Manager
Katarina Rutkowski	Working Group
Amy Crook	Working Group

Alaska Department of Fish and Game

Dan Rosenberg	Working Group

Alaska Division of Public Health

Lori Verbrugge	Working Group

National Oceanic and Atmospheric Administration

Chris Beaverson	Working Group
Mike Buchman	Working Group

United States Environmental Protection Agency

Bruce Duncan	Working Group
Julius Nwosu	Working Group

United States Fish and Wildlife Service

Deborah Rudis	Working Group
Sonce De Vries	Working Group
Kim Trust	Working Group
Jordan Stout	Working Group
Keith Mueller	Working Group

United States Navy

Dean Smith	Working Group

Shannon & Wilson Technical Team

Rone Brewer
Dawn Birkner
Mike Witter
Avra Veilleux
Tim Garlock
John Cronin
Dan Clayton

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Alaska Community Action on Toxics
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Alaska Trappers Association
Arctic Slope Native Association
Association of Village Council Presidents
Bristol Bay Native Association
Council of Athabascan Tribal Governments
Federal Aviation Administration
Maniilaq Association
Tanana Chiefs Conference
U.S. Air Force Center for Environmental Excellence
U.S. Army Corps of Engineers, Alaska District
U.S. Geological Survey – Alaska Biological Science Center
USDA Forest Service

Guidance documents are always works in progress because their validity is maintained by continual periodic updates as new data and methods become available. With this in mind, ADEC and Shannon & Wilson extend their thanks to all those who comment on and adjust this guidance in the future.

TECHNICAL BACKGROUND DOCUMENT FOR SELECTION AND APPLICATION OF DEFAULT ASSESSMENT ENDPOINTS AND INDICATOR SPECIES IN ALASKAN ECOREGIONS

1.0 INTRODUCTION

The Alaska Department of Environmental Conservation (ADEC) has overseen the investigation and cleanup of hundreds of contaminated sites across Alaska. Chemical contaminants historically released at many of these sites have had the potential to impact ecological receptors on or near the sites. Further, chemicals in the environment at many remote sites are sometimes more likely to pose an ecological threat than a human health threat because the human population is sparse. For these reasons, results of ecological risk assessments (ERAs) are often an important consideration in risk management decisions in Alaska.

An ERA is a process for estimating the potential for adverse ecological effects, such as those that might be caused by chemicals at a contaminated site. The ERA process involves many qualitative and quantitative steps, such as Problem Formulation, that are prescribed by ERA guidance (U.S. Environmental Protection Agency [EPA] 1989, 1992, 1997a, 1997b, 1998; and ADEC, 1998). Ecological risk assessments performed for sites in Alaska have historically followed national guidance. However, the need for Alaska-specific information has resulted in the recent publication of ERA guidance in ADEC's Risk Assessment Procedures Manual (ADEC, 1998). To expand this guidance, ADEC contracted Shannon & Wilson, Inc., to develop appropriate default assessment endpoints (ecological values to be protected) and indicator species (species that can be quantitatively evaluated to assess whether identified values are being protected) to be used in the performance of ERAs in Alaska. These defaults will streamline this aspect of Problem Formulation. This "Technical Background Document for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions" (Technical Background Document) presents the defaults, describes their development, and provides guidance on their application. The Technical Background Document is intended primarily for use by risk assessment professionals. A companion document entitled "User's Guide for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions" (User's Guide) (Shannon & Wilson, Inc., 1999) provides an overview for risk managers, regulated parties, consultants, and interested stakeholders who may be less familiar with the technical aspects of the ERA process. The User's Guide is also included as Appendix A of this document. Risk assessors conducting ERAs for contaminated sites in Alaska should consult both the User's Guide and this Technical Background Document.

This document was prepared by Shannon & Wilson, Inc., for the ADEC under Contract No. 18-1019-97 and constitutes Task 4, Deliverable 2, of the Ecoregions/Assessment Endpoint Project, as described in our proposal dated April 1997. This project was funded by ADEC through the Exxon Valdez Oil Spill Trustee Council and the Superfund Trust Fund (Core Program Cooperative Agreement).

1.1 Overview of the Ecological Risk Assessment Framework

Federal guidance provides a framework for conducting ERAs. This framework promotes consistency in the basic approach to be taken, but does not provide specific step-by-step details. Because of this, regional and state guidance has also been or is in the process of being completed across the U.S. and Canada. The basic federal ERA framework is reflected in Alaska's ERA guidance, but a more complete process has been defined that includes the following steps (See Figure 1-1):

- Project scoping and development of an Ecological Conceptual Site Model (CSM), including consultation with ADEC and other stakeholders to determine whether an ERA is necessary and if so, what ecological exposure pathways may need to be addressed.
- Ecological Risk Assessment Work Plan (RAWP) development, including the CSM, a Preliminary Problem Formulation, and a definition of the methods to be used to complete the ERA.
- Completion of the Risk Assessment, including an updated CSM, Final Problem Formulation, Analysis (exposure and ecotoxicity assessment), and Risk Characterization (quantitative risk estimates and qualitative risk description, including an uncertainty analysis).

Problem Formulation is a key step in which the scope and objectives of the ERA are defined. During this systematic planning step, major factors to be considered in a particular ERA are identified within the regulatory and policy context. In Alaska, Problem Formulation generally begins in coordination with project scoping and preparation of the CSM, is expanded during preparation of the RAWP, and may undergo additional revision (if new information becomes available) during the risk assessment. Preliminary Problem Formulation involves the following steps:

- Description of site history, previous investigations, land use, and regional and site-specific ecology.

- Preliminary description of contaminants of potential ecological concern (COPECs) and summary of potential associated ecological effects.

- Selection of assessment endpoints (ecological values to be protected) and associated indicator species (species that can be quantitatively assessed to determine if the identified values are being impacted).

- Selection of measurement endpoints.

- Definition of the hypotheses to be evaluated in the ERA.

Within the first step of the ERA report, the final Problem Formulation is presented. This is a refinement of the Preliminary Problem Formulation developed in the RAWP. If significant revisions to the Problem Formulation are needed because of information that was not known during the Preliminary Problem Formulation, these refinements should be submitted to ADEC for review and approval prior to continuing with the ERA.

Ecological risks at hazardous waste and petroleum sites in Alaska usually are initially evaluated in the analysis and risk characterization phases of a Tier 1 ERA, which uses the Hazard Quotient Method approach. A Tier 1 ERA generally involves exposure/food chain modeling, use of chemical analytical data for abiotic media, and use of literature toxicity benchmarks and toxic dose data. Sometimes after a Tier 1 ERA is conducted, a Tier 2 or Tier 3 ERA is conducted. This is necessary when risks are predicted during the Tier 1 ERA and more specific data is required to make appropriate risk management decisions that are protective of the environment. Tier 2 or Tier 3 ERAs often involve bioassays, biotic sampling, comparative community analysis, and/or detailed ecological field studies. Although some of the guidance in this Technical Background Document is relevant to and should be considered during the planning phase of Tier 2 or Tier 3 ERAs, the primary intent of this guidance is for use in Tier 1 ERAs.

The results of the analysis and risk characterization of the Tier 1 ERA should fulfill the objectives defined during Problem Formulation. Risk managers should be able to use the results of an ERA to determine the potential for effects related to the assessment endpoints defined during Problem Formulation. This information could be used in risk management decisions regarding the need for further ecological evaluation (i.e., Tier 2 or Tier 3 investigation), the need for remedial action, or as a basis for no further action.

1.2 Defining Assessment Endpoints and Indicator Species During Problem Formulation

The objective of this document is to identify and present default assessment endpoints and indicator species. Determination of assessment endpoints is a critical aspect of Preliminary Problem Formulation. Assessment endpoints are explicit statements of the ecological values to be protected from an ecological, cultural, societal, or legal perspective. An example of an assessment endpoint is the potential for significant adverse effects on terrestrial mammalian herbivore abundance and diversity. Assessment endpoints link risk assessment and risk management by highlighting the ecological resources that need to be protected. They are concise statements of what needs to be protected at a particular site. As such, they provide risk managers with a definition of the goals of the risk assessment. They also focus the risk assessment on the most important ecological aspects for a particular site.

Because it is not practical to estimate risks to every species potentially present at a site, one or more indicator species is generally selected in association with each assessment endpoint in order to allow quantitative evaluation of risks. An indicator species is a species used in an ERA as a surrogate for evaluating the potential impacts of stressors on a larger functional group of ecological receptors. A functional group is a set of similar species that are likely to have similar exposures to contaminants because they have similar foraging habits and are from the same trophic level (i.e., have similar diets). Generally, it is also assumed that they have similar toxicological responses, if exposed to the same chemicals in a similar fashion. For example, under conditions at a given site, risks to a squirrel would be evaluated to represent terrestrial mammalian herbivores. If no unacceptable risk was predicted for the squirrel and if a squirrel is an appropriate indicator species, it can be assumed that the site poses no threat to populations of species within the terrestrial mammalian herbivore functional group.

1.3 Objectives and Benefits

In the past, the process of selecting assessment endpoints and indicator species has been repeated at every contaminated site where an ERA is conducted. The overall objectives of the Ecoregions/ Assessment Endpoint Project were first to divide Alaska into similar biological regions or ecoregions. An ecoregion is a functional geographic unit that comprises a distinct combination of biological and physical components. The second objective was to develop preapproved lists of default assessment endpoints and associated indicator species for specific ecoregions in Alaska that are:

< Scientifically sound.
< Protective of potentially impacted ecosystems.
< Practical to implement.
< Address the concerns of state and federal agencies and other diverse stakeholders.
< Retain appropriate consideration of site-specific conditions.

The primary difference between conducting an ERA under the previous guidance versus using the Ecoregions/Assessment Endpoint approach is that the latter provides a prescreened list of default assessment endpoints and indicator species. In future ERAs conducted for contaminated sites in Alaska, the use of default assessment endpoints and indicator species defined in this document should accomplish the following:

< Streamline the Problem Formulation and thus the ERA process. It will reduce the frequency with which site-specific Problem Formulation meetings are necessary and provide detailed regional ecological information to reduce the effort required for regional ecological research in ERAs.

< Increase comparability among ERAs conducted for sites in Alaska, especially within the same ecoregion, by ensuring greater consistency in the selection of assessment endpoints by responsible parties.

< Increase consistency in ecological risk management decisions for sites in Alaska, especially within the same ecoregion, by providing a common denominator for risk management comparisons between similar sites.

< Ensure consideration of societal values.

< Streamline the ecological RAWP and Risk Assessment review process.

This approach is not intended to circumvent the consideration of site-specific information during Problem Formulation, but rather to streamline the ERA process and more reliably protect ecological resources.

1.4 Role of Stakeholders in the Development of Default Assessment Endpoints and Indicator Species

Development of the default assessment endpoints and indicator species has been based on both technical considerations and societal values. Because of this, the active contributions of a diverse group of stakeholders and a multi-agency Ecoregions Working Group have been essential to the development of the appropriate defaults.

The active stakeholder group has consisted of all respondents to an interest-level survey who indicated a willingness to actively participate. Approximately 60 organizations were surveyed, including some potentially responsible parties (e.g., private or governmental owners of contaminated sites in Alaska) and a wide variety of specialized interest groups (e.g., Alaska Native organizations; hunting, sport fishing, outdoor, recreational, or environmental groups; and commercial fishing groups). Twenty of these stakeholders indicated an interest in receiving information about the project. Individuals associated with the following twelve organizations indicated a willingness to participate more actively, either as a technical resource or peer reviewer:

< Arctic Slope Native Association
< Association of Village Council Presidents
< Maniilaq Association
< Tanana Chiefs Conference
< Council of Athabascan Tribal Governments
< Alaska Sea Otter Commission
< Alaska Trappers Association
< Alaska Community Action on Toxics
< Federal Aviation Administration
< U.S. Forest Service (USFS)
< U.S. Air Force
< U.S. Army Corps of Engineers

Stakeholders who indicated a willingness to serve as a technical resource were contacted prior to determining the default assessment endpoints and indicator species. Many of their ideas are reflected in the endpoint definition process.

The Ecoregions Working Group is a technical support team, comprised of federal, state, and other governmental agencies, that has had a key role in developing the default assessment endpoints and indicator species. The multi-agency Ecoregions Working Group was comprised of representatives of the following organizations:

< ADEC
< Alaska Department of Fish and Game (ADFG)
< Alaska Division of Public Health (ADPH)
< National Oceanic and Atmospheric Administration (NOAA)
< United States Environmental Protection Agency (EPA)
< United States Fish and Wildlife Service (USFWS)
< United States Navy (Navy)

Whenever possible, an attempt was made to reach consensus with all Ecoregions Working Group members during the determination of the approach and at key decision points within the default assessment endpoint definition and selection process.

1.5 Application of Default Assessment Endpoints and Indicator Species

The establishment of default assessment endpoints and primary indicator species and the steps involved in applying them are described in this Technical Background Document. An overview of the development of the defaults is presented in Figure 1-2 and described in detail in Appendix D. The site-specific application of these defaults includes the following basic steps:

- Step One: Determine the appropriate ecoregion for your site (Section 3.0).
- Step Two: Determine applicable default assessment endpoints and indicator species (Section 4.0).
- Step Three: Determine relevance of defaults and modify them if needed based on site conditions (Section 5.0).

These steps are shown graphically in a decision tree (Figure 1-3).

1.6 Report Organization

This report documents the following:

- An evaluation of approaches available to define selected ecoregions, the rationale for selection of eight ecoregions, the list and map of ecoregions, and the first step in applying this guidance to a site-specific ERA (Section 2.0).
- Descriptions of each ecoregion (Section 3.0).
- The approach used to establish default assessment endpoints and indicator species for each ecoregion, the results of that approach, and the second step in applying this guidance to a site-specific ERA (Section 4.0).
- Guidance for the third step in applying this guidance to a site-specific ERA, specifically, modifying defaults where appropriate under site-specific conditions (Section 5.0).
- A qualitative cost/benefit analysis (Section 6.0).

2.0 IDENTIFICATION OF ECOREGIONS

This section provides an evaluation of approaches available to define ecoregions, the rationale for selection of eight ecoregions, the list and map of ecoregions, and the first step in applying this guidance to a site-specific ERA.

2.1 Establishment of Ecoregions

Eight ecoregions were defined in Alaska for use in this project. These definitions provided a foundation for the subsequent determination of assessment endpoints that were pertinent for specific ecoregions. Various classifications of specific habitat zones in Alaska have been proposed by a number of private individuals and by NOAA (Viereck et al., 1992; Kessel, 1979; NOAA, 1987; and Walker et al., 1989). In addition, several existing techniques for defining ecoregions both in Alaska and neighboring Canada were considered, including those developed by the USFWS, ADFG, the U.S. Geological Survey (USGS), and the Canadian government.

The available habitat zone classifications provide excellent information on localized habitats, but were eliminated for consideration for use in defining ecoregions for the purposes of statewide ERA guidance for the following reasons:

- The defined habitat zones were too detailed and thus, very small. Use of these approaches would have defined an unmanageable number of ecoregions if they were applied across the entire state of Alaska.
- Each approach defines habitat zones for only specific classes of wildlife or plants and this was not inclusive of all species in Alaska.
- Two of the approaches cannot be readily applied across the entire state because they were limited in their geographic scope.

Because of their broader scope, the ecoregion approaches presented by the USFWS, ADFG, USGS, and Canada were evaluated further. In Appendix B, these techniques are summarized and evaluated for usefulness in ERA guidance based on the following criteria:

- The approach must be scientifically defensible.
- The approach should comprehensively address terrestrial, freshwater, and marine environments within Alaska.
- The technique must have support from a wide range of stakeholders.

- Whenever possible, the approach should incorporate or build upon similar efforts of other individuals and/or agencies.

- The approach should define ecoregions that are manageable in terms of number, scale, and distribution.

- To the degree feasible, the approach should be generally consistent with other related programs in Alaska (e.g., ADFG habitat management).

Based on these criteria, the USFWS approach was selected, with slight modification. Specifically, the modifications included combining marine regions with adjacent terrestrial areas and renaming the Bristol Bay/Kodiak ecoregion as the Southwest ecoregion. The major strengths of the USFWS approach include:

- Has been applied in Alaska.

- Incorporates abiotic, biotic (habitat, wildlife usage) and cultural factors.

- Comprehensively addresses terrestrial, aquatic, and marine habitat zones within Alaska.

- Addresses entire watersheds.

- Was developed with broad-based support from diverse stakeholders.

- Defines a manageable number of ecoregions.

- Is generally compatible with both the ADFG habitat management units and Canadian ecozones.

- Overall, is the most compatible approach relative to the Ecoregions/Assessment Endpoint project goals.

The eight ecoregions defined by the USFWS approach (as modified herein) include:

- Aleutian Islands
- Arctic Slope
- Interior
- Northwest
- Southcentral
- Southeast
- Southwest
- Yukon-Kuskokwim Delta

The boundaries of these ecoregions are shown in Figure 2-1. It is important to note that the USFWS ecoregions used for this project do not share the same boundaries as the five subsistence regions (e.g., Arctic-Subarctic Coast, Aleutian Pacific, Subarctic Interior, Southeast Alaska Coast, and Urban-Urban Periphery) that are to be used for human health risk assessments in Alaska.

2.2 Determining the Ecoregions in Your Site Area

The steps for application of this guidance to site-specific ERAs are depicted in Figure 1-3. Step 1 is to determine from Figure 2-1 the ecoregion in which your site is located (Decision No. 1 on Figure 1-3). Major highways, rivers, lakes, and large cities are depicted on the ecoregion map to facilitate locating your site. If your site straddles two ecoregions, compare the regional ecological descriptions provided in Section 3.0 (and Appendix C) with site-specific information to determine whether there is a unique aspect that makes your site more like one of the two ecoregions. Choose the most appropriate ecoregion given site conditions, and document the rationale; if necessary, choose both ecoregions.

3.0 DESCRIPTION OF ECOREGIONS

General descriptions of each of the eight selected ecoregions (see Figure 2-1) are provided in this section. The major habitat regimes (ecological subregions) (Gallant et al., 1995) within each ecoregion are shown in Figure 3-1 and described in additional detail in Appendix C. Because watersheds define the eight major ecoregions and vegetation types delineate the subregions, the boundaries of the two do not coincide. Therefore, a single ecoregion may encompass several subregions, and one subregion may be found in two or more ecoregions. Table 3-1 shows the correlations among ecoregions and subregions.

The descriptions of ecoregions (Section 3.0) and subregions (Appendix C) are not intended to be all-inclusive. Rather, they provide a basic description of the regional and subregional ecology. For example, some of the predominant species are described, but more complete species lists, including Latin names, are provided in Appendix D. The regional and subregional descriptions are not a substitute for thorough understanding of site conditions gained via site visits, review of previously collected data, and/or interviews with local biologists. However, they are a useful general resource for ecological risk assessors.

3.1 Aleutian Islands Ecoregion

The Aleutian Islands are volcanic in origin and are remnants of the Bering Sea land bridge that formerly connected Siberia with Alaska (see Figure 2-1). Three subregions comprise this ecoregion: the Aleutian Islands, the Bering Sea, and the Pacific Ocean (see Figure 3.1 with descriptions provided in Appendix C).

Many of the islands within the Bering Sea, including portions of the Aleutians, are included in the Alaska Maritime National Wildlife Area. These islands provide irreplaceable habitat for many species of seabirds that nest only in Alaska, as well as for marine mammals.

The Aleutian Islands include 12,000 square kilometers (km^2) of volcanic islands in the southern Bering Sea. Elevations range from sea level to 1,900 meters (m). Snow and ice mantle the higher volcanoes, and the islands have been extensively glaciated. The islands are free from permafrost, and the rivers are short, fast flowing, and commonly ephemeral. Lakes are uncommon on most of the islands, although they are sometimes found in volcanic craters (Gallant et al., 1995).

Soils are generally thin, formed from volcanic ash or cinders. Some organic soils have developed in valley bottoms and other bowl-shaped features. Soil types include Typic Haplocryands and Typic Vitricryands.

The climate of the Aleutians is maritime with four months of frost-free weather (May to September). The climate varies depending on location, but is generally cool and wet in summer. Winters may be extremely cold in the northern islands of the Bering Sea, but are generally mild in the Aleutian Islands. Pack ice extends south from the Bering Strait in winter and may cover much of the eastern portion of the Bering Sea in some years. Precipitation varies greatly from 53 to 208 centimeters (cm). Average daily temperatures are very consistent, ranging from -7 to +13°C. Temperature variation for some islands may be as little as 9°C throughout the year. Fog is common on many of the islands.

Relatively few plant taxa inhabit the Aleutian Islands. Low shrubs, grasses, and forbs dominate the treeless islands. Wet meadows and marshes cover approximately 10 percent of the land surface. The upper elevations of volcanic cones are barren and windswept with continual snow cover. At more moderate elevations, lichens, dwarf willow scrub, and crowberry scrub communities have developed. These may include species such as mountain avens, Labrador tea, mosses, cassiope, berries, and spirea. At lower elevations, moist grassland communities are dominant. Bluejoint, sedges, fireweed, and horsetail are common in the moist grasslands. Along drier coastal ridges, hair-grasses provide the dominant cover. Some wetland/bog areas are also present on the islands. These communities include berries, bog-rosemary, Labrador tea, sedges, club rush, and mosses. Aquatic plants may include mosses, liverworts, buttercup, millfoil, marigold, mare’s tail, horsetail, starwort, rushes, sedges, pondweed, bur reed, quillwort, and algae.

The freshwater macroinvertebrates of the Aleutians are not diverse. They may include annelids, nematodes, mollusks, and arthropods. Mollusks known to inhabit some islands include small and medium sized clams. Insects and crustaceans are the most common arthropods, as well as the most abundant orders of Aleutian macroinvertebrates. *Hyallela* species are commonly found in small streams of the islands, and isopods, mysids, and other amphipods also may be present. Some islands have no mosquitoes but have other insects, such as mayflies, caddis flies, blackflies, water boatmen, and beetles.

Birds are the dominant fauna on the Aleutian Islands; some islands have up to 50,000 birds. However, there are usually only a few species that make up a majority of the birds on any given island. The habitat differences between the islands dictate which species are dominant on a given island. Generally, seabirds, waterfowl, and shorebirds are common, but certain passerines such as the longspur are often the most numerous on islands with significant amounts of meadow/tundra habitats. Seabirds, waterfowl, and shorebirds may include puffins, cormorants, guillemots, loons, gulls, terns, eiders, teal, mallard, pintail, sandpipers, and phalaropes. Passerine species may include longspurs, snow buntings, finches, winter wren, and sparrows. A few birds of prey such as bald eagles, jeagers, and peregrine falcons are also found inhabiting the islands.

The only terrestrial mammals, which are found on only some of the islands, are introduced species including caribou, Norway rat, and fox. Caribou were introduced to and currently inhabit Adak Island.

Freshwater fishes of the islands include stickleback, sculpins, and Dolly Varden. Anadromous fish such as salmon may also use island streams for spawning.

3.2 Arctic Slope Ecoregion

The Arctic Slope ecoregion (see Figure 2-1) extends across northern Alaska from Cape Lisburne along the coast of the Arctic Ocean to the U.S./Canadian Border. It extends south to the crest of the Brooks Range, and then eastward along this crest back to Cape Lisburne. This ecoregion contains five subregions: the Arctic Coastal Plain, the Arctic Coastline, the Arctic Foothills, the northern portion of Brooks Range, and the Arctic Ocean (see Figure 3-1 and Appendix C). Continuous permafrost underlies the entire landward part of this ecoregion; the active layer (depth of seasonal thaw) is 0.25 to 1.25 m thick. Seventy-five percent of the region is considered wetlands, and several large rivers with sizeable deltas drain into the Beaufort Sea. The largest of these is the Colville River.

The climate of the Arctic is extremely harsh with very short summers and long, cold, windy winters. The low average daily temperatures (–30°C in winter to 8°C in summer), strong and persistent winds, and frequent cloud cover, fog, ice fog, and snow dominate the development of all ecological communities and their habits. Average annual precipitation is approximately 14 cm with 30 to 75 cm of snowfall (Gallant et al., 1995). There are 24 hours of daylight each day in June, and 24 hours of darkness each day of December.

Low diversity, slow growth, and small size are all common to the herbaceous tundra and low shrubs that cover vast areas in the region (Bliss, 1962). Much of the vegetation of the Arctic

Slope ecoregion has developed similar characteristics to handle the extreme conditions and shallow permafrost layer. The type of vegetation also is strongly influenced by changes in soil moisture content caused by microtopography such as hummocks and polygonal mounds. Structural adaptations include shallow root systems, clustering of leaves, vegetative mats, clumps or tussocks, and prostrate growth of shrubs. Physiological characteristics include the ability to store energy and grow rapidly during the short growing season. Metabolic processes also have developed to allow photosynthesis and other biochemical reactions to occur at normal rates in extreme cold conditions. The plant communities are generally considered simplistic and lack the ecological stability found in less harsh environments. This simplicity, combined with the short growing season and slow growth, makes the Arctic Slope plant communities sensitive to physical disturbance and slow to re-colonize, sometimes requiring five years or more.

Invertebrates have been estimated to be 1 to 5 percent as diverse in the Arctic as in more temperate regions (Oceanographic Institute of Washington [OIW], 1979). This trend of lower diversity increases with higher latitude. The adaptations of Arctic invertebrates include increased length of time required for the completion of a life cycle (Richards, 1963; and Oliver et al., 1964); high body concentrations of glycerol to avoid freezing; and growth of hair to retain heat. Springtails, nematodes, and mites are the primary soil invertebrates. Dipterans (true flies) are the major surface-dwelling invertebrates, of which crane flies are the most common. Aquatic invertebrate species listings were not found for this region; however, decomposers and primary consumers of planktonic species do exist within the thaw lakes and streams of the region. Regardless of their low diversity, invertebrates are an extremely important component of the Arctic Slope ecosystem. Their dramatic abundance provides the base for the Arctic food web, acting as a food source for the numerous bird species that migrate to this region.

Similar to plants and invertebrates, wildlife of the Arctic Slope have developed methods of with-standing the extreme weather conditions. Principal among these adaptations is the ability to migrate from the ecoregion during the winter, returning with precise timing to take advantage of the peak vegetation growth and invertebrate population booms that occur immediately following the spring thaw. Songbirds, shorebirds, waterfowl, and birds of prey all migrate to the Arctic. Those species that stay year-round have developed habits that promote storage of food, exploitation of prey habits and snow cover (or lack thereof), and retention of warmth through heavy fur or specialized feathers. These resident species include snowy owls, ptarmigan, ravens, and gyrfalcons.

No amphibians or reptiles are known to inhabit the Arctic Slope because of the consistently cold temperatures.

The Arctic National Wildlife Refuge occupies the northwestern portion of the Arctic Slope ecoregion. This is the northernmost wildlife refuge in the United States. This refuge is well known as the primary migration grounds for the Porcupine caribou herd. Portions of the Alaska Maritime National Wildlife Refuge occupy the northwest and southwest points of the Lisburne Peninsula. The primary species found within these shoreline refuges are seabirds and marine mammals.

3.3 Interior Ecoregion

The Interior ecoregion (see Figure 2-1) is an extremely large area that includes a majority of the Yukon and Kuskokwim River watersheds (excluding the delta regions to the west). The ecoregion is demarcated to the north by the crest of the Brooks Range, to the east by the U.S.-Canada border, and to the south by the Alaska and Wrangell-St. Elias Ranges and the northernmost portions of the Mulchatna River drainage. It extends southwest to the Kilbuck Mountains and then northward along the eastern edge of the Yukon and Kuskokwim River delta and the westernmost edge of the Yukon River watershed to the Brooks Range crest. While the U.S.-Canada border defines the easternmost portion of the Interior ecoregion within Alaska, the ecosystem extends along the Yukon drainage, well into Canada. Permafrost is continuous in the northern two-thirds of the region, and common but discontinuous in the southern third. The following nine subregions are encompassed or partly included within the Interior ecoregion: the Ahklun and Kilbuck Mountains, the Alaska Range, the Brooks Range, Interior Bottomlands, Interior Forest Lowlands and Uplands, Interior Highlands, the Ogilvie Mountains, the Wrangell Mountains, and Yukon Flats; these subregions are shown in Figure 3-1 and described in Appendix C.

Topographically, the area is comprised of extensive lowlands, undulating uplands, and the peaks and ridges of the Alaska, Brooks, and Wrangell-St. Elias Mountain Ranges. The climate is continental with hot, dry summers and bitter cold, dry winters. Temperatures range from –34°C in winter to 22°C in summer. Precipitation varies dramatically from a low of 17 cm per year to a high of up to 200 cm per year, with up to 500 cm of snow in the mountains.

The Interior ecoregion is predominantly forested by white spruce, black spruce, tamarack, paper birch, aspen, and balsam poplar. Shrub communities, bogs, sedge marshes, and wet and mesic (moist) grasslands are common within the forests. Dwarf shrub and low scrub include willows, alder, and many types of berries. Bogs are dominated by Labrador tea, berries, and mosses. Grasslands and sedge marshes are dominated by sedges and mosses. The large expanses of similar habitat types have promoted stable, well-developed biological communities, yet the presence of nine major subregions promotes diversity.

Invertebrate diversity within the Interior ecoregion is greater than that in the Arctic environment to the north, and approximates that of other temperate North American regions. Adaptations to Arctic life are not necessary in most of the ecoregion; however, many of the species that survive the Arctic environment are also common in the Interior ecoregion. Springtails, nematodes, and mites are common soil invertebrates. Mosquitoes are extremely abundant, as are other flying insects such as crane flies and blackflies. Aquatic invertebrate species are abundant in the many rivers, streams, lakes, and ponds. Invertebrates within the Interior ecoregion provide a critical food source for the abundant bird populations that migrate to this ecoregion.

Bird diversity of the Interior ecoregion reflects the high diversity of plants and invertebrates. Songbirds, shorebirds, waterfowl, wading birds, upland birds, and birds of prey all inhabit the interior of Alaska. Many of these species have resident and migratory populations. Those species that stay through the winters have developed habits to utilize many food sources, promote storage of food, exploit prey habits and snow cover (or lack thereof), and retain warmth. Several lowland subregions (e.g., Yukon Flats) within the Interior ecoregion are important as high waterfowl production areas and provide irreplaceable habitat for Canadian prairie-pothole duck populations during drought years.

Numerous species of large and small carnivorous, omnivorous, and herbivorous mammals inhabit the Interior ecoregion. Most of the mammals within this ecoregion are resident, migrating locally to prime foraging areas. The Porcupine caribou herd inhabits the far northeastern portion of the region. These caribou migrate to the Arctic coast each spring and return in the fall. For some species, the interior of Alaska represents the northernmost extent of their range.

Fish are abundant in the many lakes, streams, and rivers of the region. Both anadromous and resident species are present, including salmon, pike, rainbow trout, grayling, and whitefish.

The wood frog is a relatively common amphibian inhabitant of the Interior ecoregion.

The Interior ecoregion encompasses several national wildlife refuges. These include the Koyukuk, Kanuti, Yukon Flats, Nowitna, Innoko, and Tetlin refuges and part of the Arctic refuge. These refuges encompass nearly 20 million acres and provide habitat for representatives of nearly every species of terrestrial plant, invertebrate, wildlife, and freshwater fish found in Alaska.

3.4 Northwest Ecoregion

The Northwest ecoregion (see Figure 2-1) extends from Cape Lisburne south to Cape Stephens in Norton Sound, inland to the western edge of the Yukon River watershed, and into the adjacent ocean. It includes the Noatak and Kobuk River watersheds, other shallow drainages flowing into Norton Sound, Lisburne Peninsula, Seward Peninsula, and St. Lawrence Island.

Nine subregions are encompassed or partly included within the Northwest ecoregion: the Arctic Foothills, Arctic Ocean, Bering Sea, Brooks Range, Interior Lowlands/Uplands, Interior Highlands, Northwest Coastline/Estuary, the Seward Peninsula, and Subarctic Coastal Plain subregions, which are shown in Figure 3-1 and described in Appendix C. The Seward Peninsula subregion is dominated by treeless, low-rolling hills. The remainder of the subregion consists of Interior Forested Lowlands and Uplands. Approximately half of the Northwest ecoregion is classified as wetlands. St. Lawrence Island has a combination of habitats, including the treeless, low-rolling hills of the Seward Peninsula subregion and coastal plains more common on the Yukon-Kuskokwim Delta. The region is a transition area between the Arctic to the north and warmer climates to the south; the climate reflects this, as it is characterized by relatively cool summers and cold winters. Continuous permafrost underlies the region, but may be strongly influenced by rivers and large lakes. Average daily temperatures range from –30°C during the winter in the foothills and mountains of the Lisburne Peninsula to 8°C during the summer in Norton Sound. Average annual precipitation is similar across the ecoregion, varying from 25 to 50 cm. Snowfall varies with elevation and ranges from 25 to 100 cm. Daylight is as little as 2 hours per day in the winter and up to 24 hours per day in June.

The vegetation, invertebrates, wildlife, and fish of the northern portion of the region are often similar to those of the Arctic ecoregion, but generally are more diverse because of the slightly milder climate, especially in the southern portions of the Northwest ecoregion. The vegetation in the region is primarily either forested or low shrub/herbaceous tundra. Bogs and grassy wet meadows also are common. Changes in vegetation structure are common because topography varies considerably in this ecoregion.

Important waterfowl nesting habitat exists in lowland areas, especially in the Selawik Basin. Swans, Canada geese, and numerous waterfowl are abundant in the region. Coastal shorelines and estuaries provide irreplaceable nesting and rearing habitat for seabirds. Moist tundra in the region is important nesting habitat for shorebirds, and passerine species are common throughout the ecoregion. Predatory birds and scavengers such as jeagers, owls, and ravens are also common. The region serves as irreplaceable staging habitat for many birds migrating north to the Arctic in the spring and south in the fall.

Small and large mammals inhabit the Northwest ecoregion. Typical smaller mammals include shrews, voles, lemmings, hares, marmots, squirrels, weasel, porcupine, muskrat, and beaver. The western Alaska caribou herd is an important species that roams part of the Northwest ecosystem, and reindeer, moose, and muskoxen may also be found. Large and small predatory mammals are also present, including bears, foxes, wolves, wolverine, weasel, and mink. Marine mammals that use the coastline, lagoons, bays, inlets, and estuaries include seals and walrus.

The estuarine waters, large and small streams, lakes, and ponds provide habitat for anadromous and resident fish, including salmon, sheefish, whitefish, burbot, pike, lake trout, cisco, char, Dolly Varden, and Arctic grayling.

The wood frog may inhabit grasslands and forests of the region. No reptiles are known to inhabit the Northwest ecoregion because of its long cold winters.

The Selawik National Wildlife Refuge occupies a central location in the Northwest ecoregion. This refuge is predominantly wetlands and provides irreplaceable breeding habitat for waterfowl from North and South America, Asia, Africa, and Australia.

3.5 Southeast Ecoregion

The Southeast ecoregion (see Figure 2-1) is bordered largely by Canada to the east, and the Dixon Entrance to the south. It extends north along the coast to the town of Redwood, and includes the adjacent Pacific Ocean. The numerous islands of the Alexander Archipelago and the Pacific Coastal Mountains dominate the rugged topography of Southeast Alaska. Most of the region is mountainous, and extensive glaciers and ice fields occupy much of the mainland. A few major rivers with headwaters in Canada traverse the mainland part of this region, but most drainages are short and steep. The following four subregions are located within this ecoregion: Coastal Western Hemlock-Sitka Spruce Forests, Pacific Ocean, Pacific Coastal Mountains, and Southeast Coastline/Estuary. See Figure 3-1 for a map and Appendix C for more detailed descriptions of these subregions.

The climate is maritime with cool summers, mild winters, and abundant precipitation throughout the year. However, the Pacific Coastal Mountains rise rapidly from the shoreline, and precipitation falls as snow throughout the year on the mountain peaks. Their high elevations support year-round snow and glaciers that calve into the Gulf of Alaska.

Vegetation consists primarily of coastal western hemlock/Sitka spruce forest, bogs, and alpine tundra. The presence of fjords and islands provides for many miles of coastline. Large estuaries and saline marshes are not abundant because of the frequently steep shoreline, but are scattered throughout the region. Approximately 20 percent of the region is wetlands.

Fauna of the Southeast ecoregion includes many species dependent upon mature western hemlock/Sitka spruce forest habitats. These species include marbled murrelets, northern goshawks, Sitka black-tailed deer, and numerous passerine species. Coastal wetlands, notably the Stikine River delta, provide important resting and feeding areas for migratory waterfowl. Bald eagles nest along the coastline. Abundant salmon provide an important seasonal food resource for bald eagles, black bears, brown bears, and other species.

3.6 Southcentral Ecoregion

The Southcentral ecoregion (see Figure 2-1) is bounded to the west and north by the Alaska Range and Wrangell Mountains, to the east by the U.S.-Canada border, and extends south into the Gulf of Alaska (including Cook Inlet and Prince William Sound). This ecoregion encompasses the Copper and Susitna River watersheds. A rugged coastline to the south, glacier-clad mountains to the north, numerous fjords, and tidewater glaciers are some of the diverse landscapes of the Southcentral ecoregion. Extensive lowlands/wetlands occur around Cook Inlet and along the Copper River. Permafrost occurs sporadically. The region is mostly free of sea ice, but the upper part of Cook Inlet freezes each winter. The following eight subregions are located within this ecoregion: Alaska Range, Coastal Western Hemlock-Sitka Spruce Forests, Cook Inlet, Copper Plateau, Pacific Ocean, Pacific Coastal Mountains, Southcentral Coastline/Estuary, and Wrangell Islands. These subregions are shown in Figure 3-1 and described in Appendix C.

The climate is primarily maritime, with a transition to continental in the northern and eastern portions of the region. The weather is characterized by cool summers, relatively mild winters, and high precipitation.

Vegetation in Prince William Sound and along the eastern side of the Kenai Peninsula is predominantly western hemlock/Sitka spruce forest. White spruce, black spruce, and paper birch forests occupy the western Kenai Peninsula and around upper Cook Inlet. Twenty percent of the region is wetlands, consisting primarily of shrub-dominating bogs and open black spruce forest.

Faunal diversity is high, reflective of the habitat diversity. The Copper River Delta is of major importance as a staging area for numerous species of waterfowl and shorebirds, as the sole nesting area for dusky Canada geese, and as a premier nesting area for trumpeter swans. Cook Inlet wetlands are of similar importance as staging grounds for shorebirds and Arctic-bound geese.

Black bear, moose, and timber wolves are characteristic large mammals of the upland forest communities. Dall sheep and mountain goats occur in the mountains. Caribou and grizzly bears are found in the alpine and lowland areas. Numerous small mammals inhabit the river valleys.

River systems have tremendous fish resources, notably the world-renowned salmon of the Kenai River.

The Kenai National Wildlife Refuge occupies 1.9 million acres on the Kenai Peninsula. This refuge encompasses the Kenai River, which is world renowned for its salmon production, and protects habitat for the large resident moose population.

3.7 Southwest Ecoregion

The Southwest ecoregion (see Figure 2-1) includes the Alaska Peninsula, Kodiak Island, Shuyak Island, Afognak Island, and the watersheds of the Kvichak and Nushagak Rivers. The mountains of Kodiak Island, the volcanoes in the Aleutian Range on the Alaska Peninsula, and Iliamna and Becharof Lakes are dominant geographic features. Seven subregions are defined within the Southwest ecoregion: Ahklun and Kilbuck Mountains, Alaska Peninsula Mountains, Bristol Bay-Nushagak Lowlands, Coastal Western Hemlock-Sitka Spruce Forests, Interior Forested Lowlands and Uplands, Pacific Ocean, and Southwest Coastline/Estuary. See Figure 3-1 for a map and Appendix C for further descriptions of these subregions.

The climate is typical of coastal regions in Alaska with cool, wet summers. Winters can be cold, but are moderated by maritime influences, particularly on Kodiak Island. Habitats are varied, reflecting the diverse physiography; they include glaciers, alpine tundra, upland spruce/birch forests, lowland muskeg and tundra, and coastal wetlands. Temperate, coastal rain forests are found on Shuyak and Afognak islands and on the northern part of Kodiak Island. Approximately 40 percent of the region is classified as wetlands.

The area is renowned for its high productivity of salmon and other anadromous fish, which form the basis of a significant salmon fishery and a large tourism and sport fishing industry. Wetlands on the Alaska Peninsula are important staging habitat for waterfowl and shorebirds in preparation for their long over-water migrations to the West Coast of North America. Other notable wildlife populations inhabiting the ecoregion include Kodiak Island and Alaska Peninsula brown bears, the Mulchatna and Alaska Peninsula caribou herds, and walrus that use haulouts in Bristol Bay and on the Alaska Peninsula.

The Togiak National Wildlife Refuge occupies nearly the entire western portion of the ecoregion. The Becharof, Kodiak, Alaska Peninsula, and Izembek National Wildlife Refuges are present along the Alaska Peninsula and on Kodiak Island. These refuges total nearly 11 million acres and provide habitat for eelgrass, seabirds, waterfowl and shorebirds, large and small mammals, and marine mammals.

3.8 Yukon-Kuskokwim Delta Ecoregion

The Yukon and Kuskokwim Rivers have produced an extensive combined delta (approximately 130,000 km^2) of lowlands dominated by countless thaw and oxbow lakes. The Yukon-Kuskokwim Delta ecoregion (see Figure 2-1) extends from Stuart Island in Norton Sound, southward along the coast to central-eastern Kuskokwim Bay (Kancktok River), east-northeast to the southern crest of the Kilbuck Mountains, and finally northward across the Yukon River to Stuart Island. The majority of the delta is flat Subarctic Coastal Plains (see Figure 3-1). However, it also encompasses portions of the following additional five subregions: Ahklun-Kilbuck Mountains, Bering Sea, Interior Bottomlands, Interior Forested Lowlands and Uplands, and Yukon-Kuskokwim Delta Coastline/Estuary**.** These subregions are described in Appendix C.

The delta is characterized by vast amounts of standing water. Some of the higher areas, such as current and old riverbank mounds, and transition areas to the Kilbuck Mountains, may be dominated by needleleaf forests. Generally, the forested areas are limited by the amount of surface water found in the region, as the delta is approximately 85 percent wetlands. Nunivak Island is included in this ecoregion, and nearly all of the ecoregion is included in the Yukon Delta National Wildlife Refuge.

The ecoregion lies within a transition area between the maritime and continental climates. It has relatively mild winters and temperate summers. Continuous permafrost underlies the most of the region. Temperatures range from an average daily minimum of –25°C during the winter to 17°C in summer. Average annual precipitation varies from 50 cm in the plains to 200 cm in the mountains. Snowfall is relatively uniform across the region with an annual average of 100 to 150 cm.

The vegetation, invertebrates, wildlife, and fish of the region are diverse and abundant because of the relatively mild climate, the abundance of water, and the various available habitats. The vegetation in the coastal plains and lowlands consists primarily of sedges and low-lying species such as dwarf birch and berries, which are characteristic of Alaskan wet meadow communities. Needleleaf forests are dominated by white and black spruce and occupy less than 10 percent of the region.

No information was found specific to the Yukon-Kuskokwim Delta regarding invertebrates; however, they are expected to be numerous because of the large amounts of surface water and relatively warm summers. Mosquitoes, flies, and gnats are likely to be the most abundant species.

The amount of waterfowl habitat in the Yukon-Kuskokwim Delta is matched in Alaska only by that found on the Arctic Coastal Plain. The moderate temperatures and rainfall make the delta the most productive waterfowl nesting area in North America. Species from all continents of the Pacific Ocean migrate to the Yukon Delta to breed. Coastal shorelines (especially on Nunivak and nearby smaller islands) and nearshore areas provide irreplaceable nesting and foraging habitat for seabirds. Moist tundra in the region also provides important nesting habitat for shorebirds. Passerine species are abundant, and predatory birds and scavengers are common. The region also serves as important staging habitat for many migratory birds.

Both small and large mammals inhabit the Yukon-Kuskokwim Delta ecoregion. These species must be well adapted to the abundance of surface water. Muskox and reindeer inhabit Nunivak Island, and marine mammals use the coastline, lagoons, bays, inlets, and estuaries.

The estuarine waters, large and small streams, lakes, and ponds provide abundant of habitats for anadromous and resident fish.

The wood frog may inhabit grasslands and forests of the region. No reptiles are known to inhabit the region.

The Yukon Delta National Wildlife Refuge occupies a majority of the Yukon-Kuskokwim Delta ecoregion. This 19-million-acre refuge provides a variety of habitats for Alaskan wildlife, especially waterfowl, moose, and other water-dependent species.

4.0 DEFAULT ASSESSMENT ENDPOINTS AND INDICATOR SPECIES

This section describes the approach used to establish default assessment endpoints and indicator species for each ecoregion, the results of that approach, and the second step in applying this guidance to a site-specific ERA. An assessment endpoint was defined in Section 1.2.

4.1 Development of Default Assessment Endpoints and Indicator Species

The selection process for default assessment endpoints and primary indicator species involved combining the results from two parallel efforts from within each ecoregion: determining societal/cultural values to be protected, and describing regional ecology in order to categorize the species present within each ecoregion:

1. Research on societal and cultural values was completed for each ecoregion. This included determination of the species of concern to native and non-native cultures through telephone interviews with identified stakeholders and review of the literature (See Appendix D, Tables D.1-1 through D.1-8 and D.2-1 through D.2-8). Species of subsistence, ceremonial, recreational, commercial, and regulatory value were defined. Overall protection of ecosystem health also was considered an important societal value, and this concept underlies the overall approach to defining default assessment endpoints.

2. Descriptions of the ecology of each of the ecoregions, including species lists, were prepared. The species for each ecoregion were organized into functional groups (as defined in Section 1.3) by sorting species as follows (See Tables D.3-1 through D.3-8 in Appendix D):

    < By type (e.g., bird, mammal, etc.).

    < By the species' foraging strategy and foraging habitat association (e.g., aquatic, semiaquatic/benthic, terrestrial) and trophic level (primary producer, herbivore, detritivore, invertevore, or carnivore).

    < By foraging habitat qualifier (e.g. marine, freshwater, sediment, or soil).

Information from these two parallel efforts was combined to select a list of default assessment endpoints, one for each functional group (Tables D.4-1 through D.4-8). This effort is described in detail in Appendix D.

Default primary indicator species were then selected for each assessment endpoint based primarily on determining the single species within each functional group that was likely to have the highest potential for exposure to chemicals at any given contaminated site within the ecoregion. The primary factors related to exposure potential that were considered follow:

- Intake/exposure parameters (i.e., body size, home range)
- High density population
- Widespread occurrence in the ecoregion
- Foraging approach of the species
- Ecological niche(s) represented by a species

Other factors that may have influenced the selection of some default primary indicator species follow:

- Availability of exposure and toxicity data
- Societal value of the species (Section D.2)
- Regulatory status of species (Section D.2)

An overview of the selection process for default assessment endpoints and primary indicator species is presented in Figure 1-2. The development process for default assessment endpoints and indicator species was applied for each ecoregion. The process and results for each ecoregion are presented in greater detail in Appendix D.

4.2 Lists of Default Assessment Endpoints and Indicator Species and Determination of Which Defaults Apply to Your Site

Step 2 in the site-specific application of this guidance involves determining which defaults apply for the ecoregion in which your site is located. The default assessment endpoints and associated default primary indicator species are summarized by ecoregion in Table 4-1. Unless Table 4-1 indicates that an assessment endpoint is "not applicable" (NA) for the particular ecoregion in which your site is located, the defaults are applicable but subject to adjustment through the site-specific consideration as discussed in Section 5.0.

For certain assessment endpoints, a default primary indicator community (e.g., all terrestrial plants) rather than a default primary indicator species (e.g., squirrel) is provided in Table 4-1. The most common Tier 1 ERA assessment methods used for these particular assessment endpoints do not involve selection of indicator species because they do not involve dose modeling; rather, media concentrations are compared with criteria considered protective of a whole group or community of organisms. In fact, sometimes more than one assessment endpoint can be assessed simultaneously in the quantitative Tier 1 ERA. For example, marine aquatic plants, marine aquatic invertebrates, and marine fish are often assessed simultaneously by comparing marine water concentrations with marine water quality criteria. The most common Tier 1 ERA assessment method is indicated in Table 4-1 for informational purposes. However, the specific methods to be used to quantify the risks associated with each applicable assessment endpoint may vary and should be proposed in the RAWP. Table 4-1 also identifies the primary (in bold) and other exposure media (e.g., soil, sediment, or water) most commonly associated with a given assessment endpoint.

5.0 SITE-SPECIFIC CONSIDERATIONS AND MODIFICATION OF DEFAULTS

Step 3 in the site-specific application of this guidance is to modify default assessment endpoints and primary indicator species (from Section 4.0) for the ecoregion in which your site is located (from Sections 2.0 and 3.0). This allows for incorporation of site-specific conditions and involves four major steps:

- Step 3, Part A. Eliminate unnecessary default assessment endpoints.
- Step 3, Part B. Determine the need for additional assessment endpoints.
- Step 3, Part C. Modify default primary indicator species as needed to reflect site-specific conditions (i.e., select alternate primary indicator species).
- Step 3, Part D. Add secondary indicator species if needed.

The process is intended to proceed from a generic, all-encompassing list of possibilities to a generally smaller, site-specific list of assessment endpoints and indicator species that are applicable to a particular ERA. This process requires consideration of the site-specific ecology, current and future land use, COPECs, potential exposure media, and stakeholder concerns. Each of these aspects of a particular site should be described in the Preliminary Problem Formulation and used in the development of a CSM (just as they should be in all ERAs conducted under previous guidance). The CSM and site-specific information are then used as the primary tools for site-specific modification of or addition to the default assessment endpoints and primary indicator species.

Through this process, the default list of assessment endpoints and primary indicator species may be trimmed to the subset of endpoints and species necessary for comprehensive ecological risk assessment at the site. Ideally, the list of assessment endpoints and indicator species that is selected during Problem Formulation as part of development of the RAWP will be the same list assessed within the site-specific ERA. However, if further site information is obtained after the RAWP is completed, it may be necessary to refine the site-specific assessment endpoints and indicator species. Any refinements made after approval of the RAWP should be submitted to ADEC for review and acceptance.

The use of the descriptions of regional ecology (Section 3.0 and Appendices B and C), default functional groupings (Section 4.0 and Appendix D, Tables D.3-1 through D.3-8), and tables of default assessment endpoint and indicator species (Section 4.0 and Appendix D, Tables D.4-1 through D.4-8) will decrease the amount of documentation required within a RAWP and ERA. However, each decision made in site-specific application of the Ecoregions/Assessment Endpoint approach should be well documented within the Problem Formulation. Any deviations from or additions to the defaults also must be documented for regulatory review and approval.

The site-specific procedures for the elimination, modification, or addition of assessment endpoints and indicator species are discussed in the following subsections.

5.1 Eliminate Unnecessary Assessment Endpoints (Step 3, Part A)

Whether an assessment endpoint identified in Step 2 is relevant is determined based on the following factors:

- The CSM and site-specific food web (e.g., complete exposure pathways)
- The COPECs and their potential effects
- Physical factors and/or known site ecology
- Available and practical assessment methods
- Stakeholder concerns/cultural values

A default assessment endpoint is to be presumed relevant unless there is adequate evidence provided based on these factors to support a conclusion that it is not.

5.1.1 Conceptual Site Model

Assessment endpoints are not relevant if they pertain to functional groups that do not have a complete and potentially significant exposure pathway. The incomplete or negligible exposure pathways outlined in the CSM should be used to determine which of the regional default functional groups will not be exposed to chemicals at your site. For any functional groups that will not be exposed, the associated assessment endpoint may be removed from the default list and from further consideration. This determination is made by evaluating whether the primary associated media for each default assessment endpoint (indicated in bold in the last column of Table 4-1) are exposure media at your site; if they are not, then the associated assessment endpoints will not generally be relevant and may be removed from the default list and from further consideration. For example, if surface soil was not contaminated and therefore no complete ecological exposure pathway to soil could be identified, assessment endpoints focused on protection of terrestrial soil-associated organisms should be removed from further consideration.

5.1.2 Contaminants of Potential Ecological Concern

COPECs influence assessment endpoints because there is no need to evaluate receptor groups that are not potentially affected by site contaminants. For example, if no biomagnifying chemicals are suspected or detected, then assessment endpoints for protection of carnivorous receptors may not be toxicologically relevant (stakeholder concerns must also be considered in the selection of assessment endpoints). Although formal COPEC selection generally will not have occurred at the Problem Formulation stage, if COPECs have been selected, assessment endpoints for functional groups with primary associated media (see Table 4-1) in which no COPECs are identified may also be eliminated.

5.1.3 Physical Factors and/or Known Site Ecology

An assessment endpoint could be eliminated if it is demonstrated that no species within a functional group is potentially present at a site. However, because verification would be required, it is anticipated that assessment endpoints would not commonly be eliminated based on this criterion. Nevertheless, available site-specific information should be reviewed to determine whether there is strong evidence that a functional group would not be represented by one or more species at the site. For example, physical setting and site-specific ecological information such as habitat surveys, presence/absence surveys, trapping efforts, or other ecological field data should be reviewed. Based on these and other considerations, a determination should be made as to whether species representing the functional groups remaining from Step 3, Part A are potentially present. Functional groups demonstrated to be absent (and their associated assessment endpoints) should be removed from further consideration. Justification should be thoroughly documented for all functional groups (and thus, assessment endpoints) that are eliminated from the default list.

Physical factors and substantial knowledge of site ecology are the most common lines of evidence suitable for removing a functional group. Only if these types of factors affect an entire functional group can the assessment endpoint be eliminated; in most cases, these types of factors may simply affect the selection of indicator species (see Section 5.3).

Physical factors at a site may limit the types of receptors likely to use the site. For example, pavement, large areas of gravel/cobble/rock, structures, noise, routine human activity, fences, or other factors may minimize the likelihood that a given class of receptors will access the site on any routine basis or may otherwise minimize the concern over a receptor group. In some cases, such receptors will comprise an entire functional group.

Information on site ecology is rarely adequate to determine whether an entire functional group is present or absent. However, where sufficient evidence exists from presence/absence surveys, trapping efforts, detailed habitat surveys, and/or other ecological field data, it may be possible to eliminate an entire functional group and the associated assessment endpoint.

5.1.4 Available and Practical Assessment Methods

Certain practical constraints posed by currently available risk assessment information and approaches exist that can make evaluation of certain species impractical. In some cases, there may be no practical method to evaluate an assessment endpoint. One example is protection of epiphytic plants. Unless there is an unusual site-specific concern regarding potential impacts on epiphytic plants, this assessment endpoint will normally not need to be addressed because suitable Tier 1 ERA techniques are not currently available. Another example may be where no exposure or toxicity data exist for a species (or none that can be extrapolated from another species). This may make assessment of that species impossible. A lack of reliable bird-to-bird biotransfer factors for most chemicals also makes evaluation of raptors, whose diet is comprised primarily of birds, infeasible at the present time using Tier 1 ERA methods.

Practical aspects of the available toxicity data may make assessment endpoints and associated indicator species or communities redundant. For example, often the same toxicity data (e.g., water quality criteria) are used in Tier 1 ERAs to assess potential effects on freshwater or marine aquatic invertebrates, aquatic plants, and fish. Thus, several assessment endpoints might be addressed by using the same toxicity data. However, in this case, the individual assessment endpoints should not be removed from consideration but should be considered collectively.

5.2 Determining the Need for Additional Assessment Endpoints (Step Three, Part B)

The addition of new assessment endpoints could be warranted under site-specific conditions. This could be the case when species inhabiting a site are not presented in the regional default functional grouping table (Appendix D. Tables D.3-1 through D.3-8). On other occasions, there could be aspects of a site that need to be protected, but that are not associated with any particular species or functional group (e.g., aesthetic considerations). Also, if an endangered or threatened species is known to be present at the site, an assessment endpoint for protection of individual organisms, rather than populations, could need to be added. In this case, an assessment endpoint could be added for the site-specific ERA.

In some cases, assessment endpoints could also need to be added to meet specific goals and objectives of stakeholders and natural resource trustees For example, establishing a separate assessment endpoint because of an intense, overriding societal concern could be beneficial to the project's success even when evaluation of the default assessment endpoints would technically address the concern, but not in a way that could be readily described to stakeholders.

Any additional assessment endpoints should be included in the RAWP and the ERA itself, with an explanation of appropriate measurement endpoints and indicator species. If no need for additional assessment endpoints is identified, this should be stated in the RAWP and ERA.

The result of Step 3, Parts A and B, will be a list of the site-specific assessment endpoints representing each remaining functional group applicable to the site.

5.3 Modify Default Primary Indicator Species (Step 3, Part C)

In Step 3, Part C of this process, site-specific conditions can be used to modify the default primary indicator species associated with the functional groups/assessment endpoints remaining following Step 3, Parts A and B. This is permitted because there may be cases when a default primary indicator species is not the most appropriate species to be assessed. This is especially likely to be the case when a default indicator species does not or is very unlikely to use a particular site, or if a different species within the functional group is determined during project scoping to be very important from a risk management perspective and sufficiently protective (e.g., generally, equally, or similarly exposed) of the functional group. Therefore, where appropriate, an alternate primary indicator species may be selected on a site-specific basis to replace the default primary indicator species.

The basic process for selecting an alternate primary indicator species from the species remaining in the same functional group is to first establish that it is appropriate to replace the default primary indicator species. Then, the same factors that were applied in the selection of the default are used to select the alternate primary indicator species (See Section D.4.2.1)

Specifically, for each remaining assessment endpoint, determine whether the default primary indicator species shown on Table 4-1 (also in Appendix D, Tables D.4-1 through D.4-8) is potentially found at your site. To determine this, the physical setting and available ecological information should be reviewed by a biologist/ecologist familiar with the site and region, as well as with species habitat requirements within the region. It is important to consider whether the default primary indicator species is absent from the site because of ecological reasons and not as a result of exposure to site-related chemicals. If all the default primary indicator species are potentially present on site, the list of default primary indicator species and the assessment endpoints they represent generally should not be modified. One possible exception is an equally exposed species in the same functional group that is of very high interest to stakeholders or risk managers. From a technical standpoint, it would make little difference which species was used, but using the more valued species may make the ERA more pertinent to stakeholders.

If any of the default primary indicator species are verified and adequately documented as absent from the site for non-chemical-related reasons (e.g., based on physical factors and/or sufficient information on site ecology [see also Section 5.1.3]), they can be removed from further consideration. This leaves one or more unrepresented assessment endpoint(s) (i.e., assessment endpoint(s) without associated indicator species), so it is necessary to replace the default primary indicator species with an alternate primary indicator species from the same functional group. These alternate primary indicator species should be selected with the same considerations used to select the default primary indicator species (details of this process are presented in Appendix D, Section D.4). Generally, the alternate primary indicator species should be the most highly exposed (likely to be the smallest size) species within a functional group that has not been shown to be absent from the site. However, other considerations may include high density occurrence of the species, availability of exposure and toxicity data, societal value of the species, and regulatory status of species. In addition, the default assessment endpoints and primary indicator species provide consideration of species exposed only to marine or only to freshwater environments. They do not specifically provide for a species that may be exposed to both marine and freshwater environments at the same site. If there are no species likely to be present on site that use solely freshwater or solely marine environments, a species that may be exposed to both environments could be selected as an alternate primary indicator species. The functional grouping tables (Appendix D, Tables D.3-1 through D.3-8) include information on combined marine/freshwater exposure and may be consulted to select species that are exposed to, and can be assessed for, exposure to both environments.

The selected alternate primary indicator species will be representative of a particular assessment endpoint and also of the functional group associated with that assessment endpoint. Therefore, the alternate primary indicator species should be selected from those species listed in Appendix D, Tables D.3-1 through D.3-8, that are representative of both an assessment endpoint and its associated functional group.

5.4 Add Secondary Indicator Species (Step 3, Part D)

Sometimes in an ERA for a particular site, there is reason to select and assess the potential for risks to more than one indicator species from a given functional group. Examples of situations that might require the assessment of more than one indicator species are when an estimate is desired of the range or variability of potential risks within a functional group, or when consideration of differing foraging approaches becomes important because chemicals are present in more than one habitat type at a site. When it becomes necessary to select an indicator species for a functional group in addition to (not in place of) the default or alternate primary indicator species, the second species is called a secondary indicator species.

The selection of a secondary indicator species is not necessary at every site. Rather, it is required only when a clear need is identified during the project scoping and Problem Formulation process. Although protection of the primary indicator species normally ensures that other species within a functional group are protected, there may be either a different risk management weight given to particular species, or other site-specific circumstances which suggest that the additional effort to select and evaluate a secondary indicator species is warranted. Because secondary indicator species will be selected only when there is a specific reason to do so, the selection process and species to select are often self-evident. When a secondary indicator species is deemed appropriate, the cultural values presented in Section D.2 should be a key consideration in the selection of the secondary indicator species.

The most common basis for selection is when a species is particularly valued from a regulatory or societal standpoint. For example, risk managers may place a different weight on protection of a particularly valued species than on protection of the rest of the species in the same functional group. In such cases, the highly valued species can be selected from the functional group as a secondary indictor species. Both the primary and secondary indicators species from that functional group would be assessed in the ERA. Another example of a situation that may require selection of a secondary indicator species is when a functional group includes species that use different ecological niches than the default indicator species. For example, the default indicator species for the marine avian invertevore functional group in the Aleutian Islands gleans invertebrates from the intertidal zone and is most likely to be the highest exposed species within the functional group. If there is an indication that contaminants may be impacting the subtidal zone, then a secondary indicator species that dives and gleans invertebrates from the bottom of the subtidal zone may be required to adequately assess the potential for ecological risks.

In few cases, it may be necessary to select more than one secondary indicator species from within a functional group. However, the practice of selecting one, two, or more secondary indicator species should be minimized so that the scope of the risk assessment does not become unmanageable without adding information necessary for risk management decision-making.

The following general factors should be considered in light of the needs of risk managers/decision makers, stakeholders, and site-specific conditions in order to determine whether to use secondary indicator species in addition to default or alternate primary indicator species, and to decide which secondary indicator species to select:

- Cultural values (See Appendix D, Tables D.1-1 through D.1-8 and Section D.2)
- Differential risk management value
- Exposure potential
  - Size (It may be of risk management value to have a range of risks for different size organisms within a functional group)
  - Species with limited home range
  - A species' fidelity to a particular site
  - Resident breeding species versus transient species
- Toxicological sensitivity of species to COPECs
- Toxicologically sensitive life stages
- Inhabitants of sensitive areas
  - Use of spawning grounds at the site
  - Use of nursery habitat at the site
  - Use of rookeries at the site
- Secondary foraging strategy
- Secondary habitats
- Low density population
- Ecological niche

These considerations were identified while developing the default primary indicator species but do not necessarily apply at all sites, so they must be evaluated separately for applicability at each specific site. If any of these considerations apply to your site and influence the use or selection of secondary indicator species, the rationale should be clearly documented in the RAWP and ERA. Each of these factors, as it pertains to the decision to use secondary indicator species or their selection, is discussed below.

5.4.1 Cultural Value, Relative Risk Management Value, and Exposure Potential

To be protective of an entire functional group, it was necessary to select default primary indicator species among the most exposed species within the functional group that they represent. Generally, this resulted in selection of smaller species as default primary indicator species. Because the more culturally valued species are typically larger animals, they were generally not among the default primary indicator species. Although protection of the default primary indicator species generally will also ensure protection of the larger, more culturally valued species within the same functional group, there are times when separate evaluation of additional species within a functional group may be beneficial or important in risk management decisions. For example, risk managers may give greater importance to protecting larger animals than smaller animals, particularly where the site is sufficiently small that regional populations of small animals would not likely be affected even if the site populations were decimated. In such cases, it may be beneficial to evaluate both a small and a large indicator species for the same assessment endpoint (e.g., both a squirrel and a caribou for terrestrial mammalian herbivores). This dual assessment approach may also be of value in quantifying a range of risks within a functional group. Also, there are times where the level of stakeholder concern about a particular species, such as rare, threatened, or endangered species, may be sufficient to warrant its separate evaluation even though it is technically unnecessary, since protection of an equally sensitive, more exposed primary indicator species would ensure protection of the less exposed species with which stakeholders are concerned. In some cases, the extra level of effort may be warranted in order to provide information that is particularly pertinent to stakeholders. It must also be noted that if assessed, federally protected species must be given consideration as individuals, not as a population.

Once the decision is made to evaluate secondary indicator species, the factors influencing that decision will largely influence which additional species should be selected. Detailed species lists for each functional group are provided in Appendix D, Tables D.3-1 through D.3-8. Information on societal and regulatory values is provided in Appendix D, Tables D.1-1 through D.1-8 and Tables D.2-1 through D.2-8. Section D.2 of Appendix D also provides information on cultural values for each ecoregion. This information, along with site conditions and risk management objectives, should serve as the basis for selecting secondary indicator species, if any are needed. It is also important to identify any additional species of special concern to stakeholders during the Problem Formulation process for your site.

5.4.2 Toxicological Sensitivity

Normally, risks to small animals in the same functional group will be higher than those for large animals because the smaller animals are more highly exposed to contaminants. Therefore, the default primary indicator species is generally a smaller animal. However, this may not be protective for certain species that may be sensitive to the effects of a particular contaminant present at a site. Therefore, if a species is present at a site and is known to be sensitive to the effects of a site contaminant, then that species may also be considered a candidate secondary indicator species. Toxicological data may be found in databases such as the Registry for Toxic Effects of Chemical Substances (National Institute of Occupational Safety and Health, 1999); the Integrated Risk Information System (EPA, 1999a); the Health and Safety Data Bank (National Library of Medicine, 1999); the Aquatic Information Retrieval Database (EPA, 1999b); or from toxicity peer-reviewed literature.

5.4.3 Toxicologically Sensitive Life Stages

It is possible that particular life stages (especially larval or juvenile stages) are more likely than others to be affected by site-related contaminants. This potential is species-specific and chemical-specific. Therefore, consideration should be given to the potential for such sensitivities in the selection of secondary indicator species.

5.4.4 Sensitive Areas

If critical habitat or sensitive areas such as spawning grounds, nursery habitat, rookeries, or marine mammal haulout areas are present, specific additional species may require evaluation. Some legally defined sensitive areas are listed in ADEC’s ecological risk assessment guidance (ADEC, 1998). Ecological risk assessors or stakeholders also may identify biological sensitive areas during project scoping. One or more indicator species that inhabit the sensitive areas may then be selected as secondary indicator species if the primary indicator species does not inhabit the sensitive area.

5.4.5 Secondary Foraging Strategy

Within the functional grouping process, it was necessary to include both a primary and a secondary foraging strategy for each species because most species rely on more than one foraging approach. These foraging strategies are listed in the functional grouping tables, Appendix D, Tables D.3-1 through D.3-8. While functional grouping and selection of default primary indicator species were based on the primary foraging strategy, for particular site-specific ERAs it may be necessary or prudent to reclassify a species using its secondary foraging strategy. This would be necessary only if risks to a particular indicator species needed to be assessed for an exposure pathway that was better represented by its secondary foraging strategy. In this case, the species should be moved to, and considered representative of, the functional group and assessment endpoint defined by its secondary foraging strategy. An alternate primary indicator species should then be chosen to represent the functional group and assessment endpoint from which the species was removed.

5.4.6 Secondary Habitats

Within the functional grouping process, species were classified using habitat qualifiers. In some cases, secondary habitats were noted using a small "x" in the functional grouping table (Appendix D, Tables D.3-1 through D.3-8). These secondary habitats may be significant at a particular site and thus may require assessment. In this case, an additional indicator species may be chosen from within a functional group if it is more likely to use the habitat of interest at a site.

5.4.7 Low-density Populations

The primary default indicator species were chosen due to their likely widespread occurrence and relatively high population density. These factors are important because they generally result in more significant exposure and allow for consistent indicator species across many ecoregions. In some cases (especially for protected or sensitive species), it may be necessary to use an uncommon species (i.e., low population density) as an indicator. In this case, an additional species should be chosen from the complete site-specific species list to represent the appropriate functional group and assessment endpoint.

5.4.8 Ecological Niche

The use of more than one indicator species to address the need to assess varying exposure potential was discussed above. Two indicator species from the same functional group may also be used to assess risks to species that inhabit and forage in slightly different ecological niches that are both present at a given site and require assessment. If two niches are identified during site-specific project scoping and Problem Formulation, and COPECs are found in exposure media within both niches, then selection and assessment of secondary indicator species that represent each niche may be necessary. The final decision is to be made through discussions with stakeholders, trustees, and regulators.

Completion of Step 3, Parts C and D, determines the final list of site-specific indicator species to be carried into the risk assessment in order to address the site-specific assessment endpoints identified in Step 3, Parts A and B.

6.0 PROGRAMMATIC BENEFITS

Use of the default assessment endpoints and indicator species developed in the Ecoregions/Assessment Endpoint project is expected to result in the following benefits:

- Streamlined Problem Formulation process.
- Greater comparability of risk assessment results across sites within the same ecoregion.
- Greater consistency in risk management decisions for sites in the same ecoregion.
- Reduced uncertainty in the ERA process.
- Better incorporation of agency and diverse stakeholder concerns at all sites, especially at smaller sites where the opportunity often does not exist for substantial stakeholder input.
- Reduced costs to ADEC, other agencies, regulated parties and their consultants, and taxpayers.

Specifically, costs will likely be reduced as follows:

- ADEC
    - By facilitating quicker review of ecological RAWPs and ERAs.
    - By reducing the frequency with which site-specific problem formulations are needed.
    - By providing a framework on which additional ERA guidance, such as screening levels, can be developed.
- Other Agencies
    - By reducing the frequency with which site-specific problem formulation meetings are needed, since input from other agencies was incorporated in establishing the defaults.
- Regulated Parties and Their Consultants
    - By providing information on regional ecology, thus reducing the amount of background research required for each site-specific ERA.
    - By reducing the frequency with which site-specific problem formulation meetings are needed.
    - By increasing the likelihood and ease of initial agency approval of site-specific ecological RAWPs.
    - By providing regional species lists and functional groupings to reduce necessary background research, even where site-specific deviations from defaults are warranted.

< Taxpayers

  — By reducing costs to ADEC, other governmental agencies, and regulated parties, many of which are funded by tax dollars, for example, the U.S. Department of Energy and the military.

Cost savings will be greater once consultants and ADEC personnel have become familiar with the default approach.

7.0 LIMITATIONS AND CLOSURE

This document was prepared in accordance with our contract, proposal, and subsequent discussions with ADEC, and within the limitations of our scope and project objectives. Shannon & Wilson, Inc., has applied professional judgment, and others may or may not reach the same conclusions. Also, changes in ERA processes may occur over time that could affect the applicability of this report.

SHANNON & WILSON, INC.

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Rone Brewer
Ecological Risk Assessor

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P. Dawn Birkner
Senior Principal Risk Assessor/Project Manager

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Daniel N. Clayton
Vice President

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APPENDIX A

USER'S GUIDE FOR
SELECTION AND APPLICATION OF DEFAULT ASSESSMENT ENDPOINTS AND INDICATOR SPECIES
IN ALASKAN ECOREGIONS

TABLE OF CONTENTS

Page

LIST OF TABLES

Table

LIST OF FIGURES

Figure No.

APPENDIX A

USER'S GUIDE FOR SELECTION AND APPLICATION OF DEFAULT ASSESSMENT ENDPOINTS AND INDICATOR SPECIES IN ALASKAN ECOREGIONS

9INTRODUCTION AND OBJECTIVES

This section provides background information and an overview of the technical development process for selecting default assessment endpoints and indicator species for each ecoregion in Alaska. For technical details of the development process and site-specific use of the default assessment endpoints and indicator species, refer to the accompanying Technical Background Document (Shannon & Wilson, Inc., 1999).

9.1 Overview of Ecological Risk Assessment Framework

Ecological risk assessment (ERA) is a process for estimating the potential for ecological effects, such as those that might be caused by chemicals at a contaminated site. ERAs are necessary at many, though not all, contaminated sites in Alaska. Concurrence with the Alaska Department of Environmental Conservation (ADEC) should be reached regarding whether an ERA is needed for a particular site.

The basic framework for ERAs in Alaska includes the following steps (see Figure A.1-1):

- Project scoping.
- Conceptual site model (CSM) development.
- Ecological Risk Assessment Work Plan.
- Problem Formulation (including site-specific ecological description and selection of assessment endpoints [values to be protected] and indicator species).
- Analysis (assessment of exposure and ecotoxicity).
- Risk Characterization (the calculation of estimated risk and qualitative description of the risks, including uncertainties in the risk estimates).

According to the Risk Assessment Procedures Manual (ADEC, 1998), the proper procedure for a risk assessment for a contaminated site in Alaska is to prepare a CSM, followed by a Risk

Assessment Work Plan (RAWP), including Preliminary Problem Formulation and method description for the Analyses and Risk Characterization. Once agency approval of the RAWP is obtained, then preparation of the risk assessment report can proceed.

9.2 Overview of Problem Formulation

Problem Formulation is a key part of an ERA during which the scope and objectives of the ERA are defined. Problem Formulation generally is initiated with the preparation of the CSM and expanded during preparation of the RAWP. Minor modifications to the Problem Formulation may also occur in the ERA report as new information becomes available. Any refinements made after approval of the RAWP must be submitted for review and acceptance by ADEC.

One aspect of Problem Formulation for a site, involves selection of assessment endpoints. Assessment endpoints are explicit statements of the ecological values to be protected. An example of an assessment endpoint is the potential for significant adverse effects on terrestrial mammalian herbivore (e.g., land mammals that primarily consume vegetation) abundance and diversity. Because it is not practical to estimate risks to every species potentially present at a site, one or more indicator species is generally selected in association with each assessment endpoint in order to allow quantitative evaluation of risks. For example, under conditions at a given site, a squirrel might be selected to represent land mammals that consume vegetation. Then, risks for a squirrel would be evaluated. If no unacceptable risk is predicted for the squirrel and if a squirrel is an appropriate indicator species, it can be assumed that no threat exists to populations of land mammals that consume vegetation.

9.3 Establishing Default Assessment Endpoints and Indicator Species

In the past, the process of selecting assessment endpoints and indicator species has been repeated at every contaminated site where an ERA is conducted. However, in future ERAs conducted for contaminated sites in Alaska, default assessment endpoints and indicator species may be used. Default assessment endpoints and indicator species were established for use in ERAs for contaminated sites in Alaska to accomplish the following objectives:

< Streamline the Problem Formulation and thus the ERA process.

< Increase comparability among ERAs conducted for sites in Alaska, especially within the same ecoregion.

< Increase consistency in ecological risk management decisions for sites in Alaska, especially within the same ecoregion.

- Ensure consideration of societal values, even at smaller sites where stakeholder participation is often minimal or nonexistent.
- Streamline the RAWP and Risk Assessment review process.

This approach is not intended to circumvent the consideration of site-specific information during Problem Formulation, but rather to streamline the selection and regulatory approval of assessment endpoints and indicator species. This User's Guide provides an overview of the site-specific use of the established defaults, including methods for modifying defaults where appropriate. It is intended to provide an overview for risk managers, regulated parties, consultants, and interested stakeholders. A companion document, "Technical Background Document for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions" (Technical Background Document; Shannon & Wilson, 1999), describes the criteria by which ecoregions, default assessment endpoints, and default indicator species were chosen. The Technical Background Document also describes the ecology of each ecoregion, provides detailed species lists by functional group (e.g., terrestrial mammalian herbivore) for each ecoregion, and discusses in greater detail the site-specific use of and modification to the defaults. Risk assessors conducting ERAs for contaminated sites in Alaska should not rely solely on this User's Guide, but should also consult the Technical Background Document to ensure that site-specific or other factors are not overlooked.

Development of the default assessment endpoints and indicator species was based on both technical considerations and societal values. An overview of this process is shown in Figure A.1-2. Because of this, the active contributions of a diverse group of stakeholders and a multi-agency Ecoregions Working Group were essential to the development of the defaults. The active stakeholder group consisted of all respondents to an interest-level survey who indicated a willingness to actively participate. Approximately 60 organizations were surveyed. Twenty of these indicated an interest in receiving information about the project. Individuals associated with the following organizations indicated a willingness to participate more actively, either as a technical resource or peer reviewer:

- Arctic Slope Native Association
- Association of Village Council Presidents
- Maniilaq Association
- Tanana Chiefs Conference
- Council of Athabaskan Tribal Governments
- Alaska Sea Otter Commission
- Alaska Trappers Association

- Alaska Community Action on Toxics
- Federal Aviation Administration
- U.S. Forest Service (USFS)
- U.S. Air Force
- U.S. Army Corps of Engineers

Stakeholders who wished to provide technical support were contacted prior to determining the default assessment endpoints and indicator species. Many of their ideas are reflected in the endpoint definition process.

The Ecoregions Working Group has had a key development role in the establishment of default assessment endpoints and indicator species. The multi-agency working group is comprised of representatives of the following organizations:

- ADEC
- Alaska Department of Fish and Game (ADFG)
- Alaska Division of Public Health (ADPH)
- National Oceanic and Atmospheric Administration (NOAA)
- United States Environmental Protection Agency (EPA),
- United States Fish and Wildlife Service (USFWS)
- United States Navy (Navy)

9.4 Use of Default Assessment Endpoints and Indicator Species

The steps involved in applying the established defaults follow:

- Step One: Determine the ecoregion in which your site is located.
- Step Two: Determine applicable default assessment endpoints and indicator species.
- Step Three: Determine relevance of defaults and/or modify them based on site-specific conditions.

These steps are briefly described in the remaining sections of this User’s Guide and are depicted on Figure A.1-3.

10STEP ONE: DETERMINE ECOREGION IN WHICH YOUR SITE IS LOCATED

The first step in selecting assessment endpoints and indicator species for your site is to determine the ecoregion in which your site is located. Several possible approaches to selecting ecoregions were considered, and a modification to the USFWS (unpublished) approach was selected (see Section 2.0 of the Technical Background Document). Based on this approach, the following eight ecoregions were defined:

< Aleutian Islands
< Arctic Slope
< Interior
< Northwest
< Southcentral
< Southeast
< Southwest
< Yukon-Kuskokwim Delta

Each of these ecoregions and the habitat types (i.e., ecological subregions) they encompass are described in detail in Section 3.0 and Appendix C of the Technical Background Document, respectively. Table A.2-1 provides a list of the ecological subregions present within each Alaskan ecoregion. To determine the ecoregion in which your site is located, refer to Figure A.2-1, which shows the extent of each ecoregion. Major highways, rivers, lakes, and large cities are depicted on the ecoregion map to help locate your site. If your site straddles multiple ecoregions (Decision No. 1), each ecoregion should be considered (see Technical Background Document, Section 2.0 for further details).

11STEP 2: DETERMINE POTENTIALLY APPLICABLE DEFAULT ASSESSMENT ENDPOINTS AND INDICATOR SPECIES

The second step in selecting assessment endpoints and indicator species for your site is to select the default assessment endpoints and primary indicator species that apply to the ecoregion in which your site is located. All default assessment endpoints in Table A.3-1- apply to a given ecoregion unless “Not Applicable (NA)” is indicated.

Note that for certain assessment endpoints, a default primary indicator community (e.g., all terrestrial plants), rather than a default primary indicator species (e.g., squirrel), is provided. The most common Tier 1 ERA assessment methods (see Table A.3-1) used for these particular assessment endpoints do not involve selection of indicator species because they do not involve dose modeling; rather, media concentrations are compared with criteria considered protective of a whole group or community of organisms. In fact, sometimes several such assessment endpoints can be assessed simultaneously in the quantitative Tier 1 ERA. For example, marine aquatic plants, marine aquatic invertebrates, and marine fish are often assessed simultaneously by comparing marine water concentrations with marine water quality criteria. The most common Tier 1 ERA assessment method indicated in Table A.3-1 is provided only for informational purposes only; the specific methods to be used to quantify the risks associated with each applicable assessment endpoint should be proposed in the RAWP. Table A.3-1 also identifies the primary (in bold) and other exposure media most commonly associated with a given assessment endpoint.

12STEP 3: DETERMINE THE RELEVANCE OF DEFAULTS OR MODIFY DEFAULTS BASED ON SITE CONDITIONS

This section outlines the approach to be used to determine the relevance of applicable default assessment endpoints (Step 3, Part A); to determine if additional assessment endpoints should be added (Step 3, Part B); to modify default indicator species identified under Step 2 to reflect site-specific conditions (Step 3, Part C); and to add secondary indicator species (Step 3, Part D). The process is to proceed from a generic, all-encompassing list of possibilities to a potentially smaller, site-specific subset of assessment endpoints and indicator species necessary for a comprehensive ERA at a site. The CSM and site-specific ecological information are the primary tools used for determining the relevance of assessment endpoints and for modifying indicator species.

The use of the descriptions of regional ecology, default functional groupings, and default assessment endpoint and indicator species tables provided in the Technical Background Document will reduce the amount of documentation required within a RAWP and ERA. However, each decision (and the associated rationale) made in site-specific application or modification of the defaults (including any deviations, additions, or eliminations) must be well-documented within the Problem Formulation; ADEC approval should be obtained before proceeding with the ERA.

12.1 Step 3, Part A: Determine the Relevance of Default Assessment Endpoints

Whether an assessment endpoint identified in Step 2 is relevant is to be determined based on the following factors:

- The CSM (Decision No. 2 on Figure A.1-3).
- The chemicals of potential ecological concern (COPECs) (Decision No. 2 on Figure A.1-3).
- Physical factors and/or known site ecology (Decision No. 3 on Figure A.1-3).
- Available assessment methods (Decision No. 3 on Figure A.1-3).

A default assessment endpoint is to be assumed relevant unless there is adequate evidence provided based on these factors to determine that it is not.

12.1.1 Conceptual Site Model

The CSM identifies complete and incomplete exposure pathways. If there is no complete exposure pathway, risk does not need to be quantified. Therefore, assessment endpoints pertaining to functional groups to which no complete and potentially significant exposure pathway exists are not relevant and may be eliminated. That is, if none of the primary associated media (indicated in bold in the last column of Table A.3-1) are exposure media at a site, then that assessment endpoint would not be relevant and may be removed from the default list and from further consideration. For example, if surface soil is not contaminated and therefore no complete ecological exposure pathway to soil is identified, assessment endpoints focused on protection of terrestrial soil-associated organisms may be removed from further consideration. Another example would be if no freshwater bodies are potentially impacted by site contaminants. In this case, assessment endpoints focused on protection of freshwater semiaquatic, aquatic, or benthic organisms would not be relevant.

12.1.2 Contaminants of Potential Ecological Concern

COPECs may also influence assessment endpoints. For example, if no biomagnifying chemicals are suspected or detected, then assessment endpoints for protection of carnivorous receptors may not be relevant. Although formal COPEC selection generally will not have occurred at the Problem Formulation stage, if it has occurred, assessment endpoints for functional groups with primary associated media in which no COPECs are identified may also be eliminated.

12.1.3 Physical Factors and/or Known Site Ecology

An assessment endpoint can be eliminated if it is demonstrated that no species within a functional group is potentially present at a site. However, because substantial evidence will be required to demonstrate a lack of species, it is anticipated that assessment endpoints will seldom be eliminated based on this criterion. Physical factors and substantial knowledge of site ecology are the most common lines of evidence suitable for making this demonstration. Only if these types of factors affect an entire functional group can the assessment endpoint be eliminated; in most cases, these types of factors may simply affect the selection of indicator species.

Physical factors at a site may limit the types of receptors likely to use the site. For example, pavement, large areas of gravel/cobble/rock, structures, noise, routine human activity, fences, or other factors may minimize the likelihood that a given class of receptors will access the site on a routine basis, or may otherwise minimize the concern over a receptor group. Some examples of the influence of physical factors include the following:

- If the site habitat consists of mowed grass, protection of plant communities may not apply.

- If the soil consists of cobble and rock with little or no fines, it may not support soil invertebrate populations. Flying insects might be present in such areas, but are unlikely to have substantial exposure to soil-bound contaminants. Therefore, assessment endpoints for protection of soil invertebrates and terrestrial avian and mammalian invertevores may not apply under such conditions.

- If the site is fenced, large animals may not be able to routinely access the site.

- If human activity and noise levels are high, more reclusive animals such as wolverines and wolves are unlikely to be present.

Information on site ecology is rarely adequate for most hazardous waste and petroleum sites to determine whether an entire functional group is present or absent. However, where sufficient evidence exists from presence/absence surveys, trapping efforts, detailed habitat surveys, and/or other ecological field data, it may be possible to eliminate an entire functional group and the associated assessment endpoint.

12.1.4 Available Assessment Methods

In some cases, there may be no practical method to evaluate an assessment endpoint. One example is protection of epiphytic plants. Unless there is an unusual site-specific concern regarding potential impacts on epiphytic plants, this assessment endpoint will normally not need to be addressed, because suitable Tier 1 ERA techniques are not currently available.

12.2 Step 3, Part B: Determining the Need for Additional Assessment Endpoints

The addition of new assessment endpoints could be appropriate under site-specific conditions (Decision No. 4 on Figure A.1-3). For example, if an endangered or threatened species is known to be present at the site, an assessment endpoint for protection of individual organisms, rather than populations, may need to be added. In some cases, assessment endpoints may also need to be added to meet specific goals and objectives of stakeholders and natural resource trustees (e.g., aesthetic considerations, for example). Similarly, there may be a need for an additional assessment endpoint based on the presence on site of an unusual species that is not represented by the default assessment endpoints. In some cases, adding an assessment endpoint may be technically unnecessary, but beneficial to site managers in order to address the concerns of site-specific stakeholders. For example, establishing a separate assessment endpoint because of an intense, overriding societal concern even when evaluation of the default assessment endpoints would technically address the concern, but not in a way that is intuitive.

The result of Step 3, Parts A and B, will be a list of the site-specific assessment endpoints.

12.3 Step 3, Part C: Determine the Relevance of and Modify Default Primary Indicator Species

The default primary indicator species (or communities) associated with the list of site-specific assessment endpoints should be evaluated in light of site conditions to determine whether any modifications are needed (Decision No. 5 on Figure A.1-3). The defaults were selected to be generally appropriate for most sites. However, it is essential to determine if site-specific modifications are needed. This may require selecting a different or alternate primary indicator species. This process is briefly described below; the Technical Background Document should be consulted for further details.

The third step in selecting site-specific assessment endpoints and indicator species is to verify that each of the default primary indicator species has some potential to be found at your site. Physical setting and available ecological information, as well as species habitat requirements within the region, should be reviewed by a biologist/ecologist familiar with the site and region. If information is sufficient to verify that any of the default primary indicator species are absent from the site for non-chemical-related reasons, those species should be removed from further consideration. Because this would leave one or more unrepresented assessment endpoints (i.e., assessment endpoint[s] without associated indicator species), it is necessary to select a replacement for the default primary indicator species. The replacement for the default primary indicator species, termed an alternate primary indicator species, generally should be the most highly exposed species (likely to be the smallest size) species within the functional group that has the potential to inhabit or use the site.

12.4 Step 3, Part D: Determine the Need for and Select Secondary Indicator Species

Depending on site conditions, it may be necessary to select more than one indicator species per assessment endpoint (Decision No. 6 on Figure A.3-1). The additional indicator species are termed secondary indicator species. It is necessary to determine whether to evaluate any secondary indicator species and to select the secondary indicator species to be evaluated. Secondary indicator species generally need to be selected only when their evaluation is likely to provide information of use in risk management decisions. To determine whether to use secondary indicator species, in addition to primary indicator species, the following factors should be considered in light of the needs of risk managers/decision makers and site-specific conditions:

- Cultural values
- Differential risk management values
- Exposure potential
- Toxicological sensitivity
- Sensitive areas
- Secondary foraging strategy
- Secondary habitats
- Marine and freshwater (dual habitat) exposure
- Low-density population
- Ecological niche

Because these factors do not necessarily apply at all sites, they must be evaluated separately for applicability to a specific site. These conditions were identified during the process of developing the default assessment endpoints and indicator species. If any of these considerations apply to your site and influence the use or selection of secondary indicator species, the rationale should be clearly documented in the ecological RAWP or ERA. Each of these factors, as they pertain to the decision to use secondary indicator species, is discussed in more detail in Section 5.4 of the Technical Background Document.

If secondary indicator species are determined to be necessary or desirable, the additional indicator species may be chosen from the species list provided in Appendix D of the Technical Background Document (Tables D.3-1 through D.3-8). Guidance on their selection is provided in Section 5.4 of the Technical Background Document; however, their selection will be largely site-specific.

The retained default or alternate primary indicator species, as well as any additional secondary indicator species, comprise the final list of site-specific indicator species to be carried into the ERA. The ecological RAWP should fully document the derivation of this site-specific list.

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APPENDIX B

APPROACH FOR IDENTIFICATION OF ALASKAN ECOREGIONS

TABLE OF CONTENTS

LIST OF FIGURES

ATTACHMENT

ABBREVIATIONS AND ACRONYMS

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
km	kilometer
NOAA	National Oceanic and Atmospheric Administration
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

APPENDIX B

APPROACH FOR IDENTIFICATION OF ECOREGIONS

14INTRODUCTION

To allow default assessment endpoints and indicator species to be selected by region, it was necessary to define ecoregions in Alaska. Several existing techniques for defining ecoregions both in Alaska and neighboring Canada are summarized and evaluated in this appendix. The rationale for selecting which of these approaches to use in ecological risk assessment (ERA) guidance in Alaska is also presented. Eight ecoregions were defined using this approach.

A number of public entities have previously defined ecoregions within the state of Alaska for a variety of different objectives. Ecoregions have been identified by the U.S. Fish and Wildlife Service (USFWS), Alaska Department of Fish and Game (ADFG), and the U.S. Geological Survey (USGS). In each case, objectives associated with particular land uses played a key role in the definition of ecoregions. Ecoregion delineations were also based on resource management goals, geology, vegetation types, habitats, wildlife use, subsistence use, and watersheds. Similar criteria have been applied in Canada for defining ecoregions.

Various classifications of specific habitat zones in Alaska have been proposed by a number of private individuals and by the National Oceanic and Atmospheric Administration (NOAA) (Viereck et al., 1992; Kessel, 1979; NOAA, 1987; and Walker et. al., 1989). The extensive volume of literature of this type precludes its comprehensive evaluation in this appendix. Rather, only the following selected examples were considered:

- Viereck et. al. (1992) provides detailed descriptions and multi-tiered classifications for habitat zones across Alaska for plants.
- Kessel (1979) provides detailed descriptions and multi-tiered classifications for habitat zones across Alaska for birds.
- NOAA (1987) defines habitat zones within specific subregions of Alaska for salmonids in southeast Alaska.
- Walker et al. (1989) defines habitat zones within specific subregions of Alaska for wetland plants in the Arctic Foothills.

These four approaches provide excellent information on localized habitats. However, they were not considered further for use in defining ecoregions for the purpose of statewide ERA guidance for the following reasons:

- The high resolution of the defined habitat zone precludes their graphical presentation at the statewide level.
- Each approach defines habitat zones for only specific classes of wildlife or plants.
- Two of the approaches cannot be readily applied across the entire state because they were limited in their geographic scope.

Because of their broader scope, the USFWS, ADFG, USGS, and the Canadian approaches were evaluated further. These techniques are summarized in Section B.2 and evaluated using specific criteria discussed below.

In order to define ecoregions most appropriate for the objectives of this study, the ERA framework (EPA, 1992; EPA, 1997; and EPA, 1998) for the selection of assessment endpoints was considered:

- Assessment endpoints should be ecologically relevant.
- Assessment endpoints should reflect policy (both regulatory and management) and societal (cultural, commercial, or recreational) values.
- Assessment endpoints should be defined in order to address both exposure to a stressor (e.g., bioaccumulation/biomagnification) as well as the specific effect(s) resulting from that exposure (e.g., toxicological manifestations of exposure, such as eggshell thinning).

The criteria developed to select the technique to be used for defining ecoregions in the ADEC ERA program follow:

- The approach must be scientifically defensible.
- The approach should comprehensively address terrestrial, aquatic, and marine environments within Alaska.
- The technique must have support by a wide range of stakeholders.
- Wherever possible, the approach should incorporate or build upon similar efforts of other individuals and/or agencies.

< The approach should define ecoregions that are manageable in terms of number, scale, and distribution.

< To the degree feasible, the approach should be generally consistent with other related programs in Alaska (e.g., ADFG Subsistence Program).

15SUMMARY OF TECHNIQUES TO DEFINE ECOREGIONS

15.1 USFWS Ecosystem Approach

The USFWS defined ten ecosystems (seven terrestrial, two marine, and one terrestrial island/marine) in Alaska (see Figure B.2-1) (USFWS, 1994a) for use in the USFWS Ecosystem Management Program. The goal of the USFWS ecosystem management program is to conserve biological diversity through perpetuation of dynamic, healthy ecosystems. To this end, the Alaska Region of the USFWS is working to: (1) identify and meet fish and wildlife needs in the context of the entire environmental and socioeconomic landscape in which they occur, (2) increase cross-program collaboration within the agency, and (3) communicate, coordinate, and collaborate more frequently, more consistently, and more effectively with their partners (other natural resource trustees), affected stakeholders, and the public. The USFWS originally developed the ecosystem approach for use throughout the United States. The method divides ecosystems primarily based on hydrographic units. Additional factors used to define each ecosystem include climate and biota. Because of the unique nature of Alaska, the approach was modified to reflect the following additional criteria:

< Significance of resource(s).

< Degree of risk (either perceived or anticipated) to the resources that is posed by current and planned land use practices (e.g., mining and logging); transportation corridors (e.g., chemical transport, new roads that provide access to previously inaccessible areas, or the potential environmental impact associated with spills or releases); and other human activity (e.g., commercial fishing, recreation, pollution, or introduction of nonnative species).

< Legal mandates/likelihood of success in management.

< Opportunities for partnership (working together with other agencies that have legally mandated management authority in order to further USFWS goals).

< Cultural considerations (e.g., subsistence by indigenous peoples).

Size was not used as a selection criterion. This resulted in defining single ecosystems that span many plant communities, as well as multiple ecosystems that share a single plant community.

The predominant criterion was watershed-based. The result was the separation of most of the major watersheds in Alaska. The main exceptions to this are:

- The consolidation of the upper Yukon and Kuskokwim drainages into one ecosystem.
- The consolidation of the Yukon and Kuskokwim River Deltas into one ecosystem.
- The consolidation of the Kobuk and Noatak drainages into one ecosystem.

Once the preliminary list of ecosystems was proposed by USFWS, the final boundary lines were defined through a consensus process. This process involved approximately 63 statewide stakeholders. In addition, ecoregion-specific stakeholders ranging in number from 24 (Arctic Ecosystem) to 98 (Interior Ecosystem) member organizations were assembled to establish the final ecosystem boundaries (USFWS, 1994b). A list of statewide and ecosystem-specific stakeholders involved in the USFWS approach is presented in an attachment to this appendix.

15.2 USGS Ecoregion Approach

The USGS defined 20 ecoregions in Alaska: Arctic Coastal Plain, Arctic Foothills, Brooks Range, Interior Forested Lowlands and Uplands, Interior Highlands, Interior Bottomlands, Yukon Flats, Ogilvie Mountains, Subarctic Coastal Plains, Seward Peninsula, Ahklun and Kilbuck Mountains, Bristol Bay-Nushagak Lowlands, Alaska Peninsula Mountains, Aleutian Islands, Cook Inlet, Alaska Range, Copper Plateau, Wrangell Mountains, Pacific Coastal Mountains, and Coastal Western Hemlock-Sitka Spruce Forests (Gallant et al., 1995). The goal of the ecoregion delineation was to provide... "a framework for organizing and interpreting environmental data for state, national, and international inventory, monitoring and research efforts." The ecoregions are defined primarily based on the distribution patterns of abiotic factors, including climate (seasonal and annual temperatures, rain, and snow); terrain/physiography (land surface forms, topography, elevation, amount of relief, and local surface irregularities); geology (surface and bedrock); glaciation; permafrost; hydrological features; and soils. A single biotic component (the distribution of plant communities) was also incorporated into the ecoregion delineation.

To define ecoregions, various mapping surveys of land features combined with climatic data were used to define areas where distinct combinations of environmental factors coincide. While the abiotic factors were, in many cases, characterized throughout the state, plant community distributions were available for only selected areas. Therefore, the incorporation of plant community data into the USGS ecoregions approach required significant extrapolation based on the authors' understanding of a region's limiting factors and the known requirements of plants within a given community. The USGS ecoregion map is presented in Figure B.2-2.

Three ecoregion components that were not incorporated into the USGS approach are wildfire occurrence (natural or human-caused), land use, or wildlife presence/use. The USGS approach provides considerable information on the distribution of various terrestrial habitat zones, but does not directly address the terrestrial wildlife usage patterns within each region and does not consider the marine environment.

15.3 ADFG Habitat Management Approach

The ADFG Habitat Management Approach defines six regions in Alaska (ADFG, 1986a and 1986b), including southeast, south-central, southwest, western, Arctic, and interior. The primary purpose of this approach is to ... "offer land management options for mitigating impacts to Alaska's fish and wildlife resources." This system's primary emphasis is on commercial and subsistence species and the potential impacts of various land use decisions on their habitats. These regions were defined by the jurisdictions of the Regional Subsistence Councils of the State Fish and Game Advisory Committee and Regional Council system (IDM, 1997). The ADFG boundaries (Figure B.2-2) are based largely on physiographic and socio-cultural similarities. However, only limited documentation is available on the rationale for the delineation. While some consideration is given to chemically-induced impacts, the primary emphasis of the program is to mitigate the physical impacts associated with various land use practices.

15.4 Canadian Ecological Stratification Working Group: A National Ecological Framework for Canada

In 1995, the Canadian Centre for Land and Biological Resources Research (CCLBRR) published an ecosystem classification system specific to Canada (Ecological Stratification Working Group, 1995). This system was devised to guide future ecological inventories and to interact with existing economic and social databases. The CCLBRR approach provides a hierarchy of defined areas so that it may be used for broadly defined regional goals as well as site-specific management objectives. At a minimum, each tier of the hierarchy uses climate, vegetation, landforms/soils, wildlife usage, and human activity-based criteria to define functional areas.

This method divides Canada into three general tiers: ecozones, ecoregions, and ecodistricts. The broadest tier, an ecozone, is differentiated primarily based on climate. The distribution of plant communities is generally based on the author's knowledge of regional limiting factors and the resource needs of specific plant communities. Landform and soils distinctions are based on surveys performed throughout Canada. Wildlife considerations generally emphasize the documented abundance of the most important ecological species. Human activity considerations are based primarily on population density, economics, and subsistence data. To date, 15 ecozones, 194 ecoregions, and 1,020 ecodistricts have been identified across Canada.

Of the 15 ecozones delineated for Canada, four abut Alaska's eastern boundary, including Taiga Cordillera, north of the latitude of Fairbanks; Boreal Cordillera, south of the latitude of Fairbanks; Southern Arctic, 150 km inland/south from the Beaufort Sea; and Pacific Maritime, for the southwestern part of the Canadian coast. Ecoregions within each ecozone are determined based on an analysis of the same factors, but at a smaller scale, generally conforming to the dominant local landform boundary (watershed). The three ecozones that abut the eastern Alaska boundary are each broken into 10 or more ecoregions. These ecoregions are further divided into ecodistricts. Ecodistricts are at a level of scale associated with individual plant assemblages, soil associations, or wildlife habitat areas.

Boundary lines for ecozones roughly follow earlier versions produced by the Canada Committee on Ecological Land Classification (CCELC) in 1976. This effort was the first attempt by Canada to focus national resource management decisions within an ecological framework. The refinement of these boundaries and the addition of the nested hierarchy involved extensive stakeholder participation, database integration, and thematic studies meant to focus decision makers' attention on specific ecosystems or ecosystem attributes. The resulting nested hierarchy is designed to be adaptive and responsive to ongoing monitoring, research, and social needs at each of the important land use scales.

16EVALUATION OF TECHNIQUES

While all of the approaches described in Section B.2 comprehensively address the terrestrial ecosystems within Alaska (or in the case of the Canadian approach, could be applied to Alaska), both the USGS and ADFG approaches lack a defined emphasis on marine ecosystems. This is an important distinction for a number of reasons:

- Alaskan marine waters support a highly diverse range of marine organisms, including many protected species that are rare or endangered elsewhere in the U.S.
- Alaska's marine ecosystems are important to a variety of migrating fish and bird species, in addition to resident marine organisms.
- A significant percentage of the contaminated sites in Alaska are located on or near the coast.
- A significant percentage of contaminated sites in Alaska are located along rivers that drain into marine waters.
- Alaska's economy is heavily dependent on the marine environment through commercial, subsistence, and recreational fishing and ecotourism.

The terrestrial habitat regions that USFWS identified are generally consistent with those defined by ADFG. The main difference is in the consolidation by ADFG of the Arctic and Northwest Ecosystems (as defined by USFWS) into one habitat region. With the exception of other minor, localized differences in regional boundaries, the ecoregions identified by the two approaches are generally comparable.

The major difference between the USGS and USFWS approaches is that the USFWS approach is broader in its definition of ecosystems. In several instances, one USFWS ecoregion encompasses two or more USGS ecoregions. One distinction in the USGS approach not incorporated into the USFWS approach is that of elevation. This results in the consolidation of a number of mountainous and lowland ecoregions under the USFWS approach. Although this difference could be very important for some applications, it is not critical for the purposes of most ERAs for contaminated sites in Alaska, because only a limited number of the contaminated sites in Alaska are located in mountainous regions. The most significant difference between the two approaches is for the USFWS Interior Ecosystem, which encompasses five USGS ecoregions. Elevation is a key factor in distinguishing the five USGS ecoregions, although hydrological characteristics were also an important factor in the bottomlands. The USGS considered primarily abiotic factors, with only limited consideration of biotic factors. Other differences between the USFWS and USGS approaches exist, but it is beyond the scope of this appendix to provide a comprehensive discussion of the differences between the two systems because of the complexity of the USGS approach.

Because of the broad range of components considered and the level of detail developed in the tiered or hierarchical approach, the Canadian approach is conceptually appealing. However, its application in Alaska beyond the ecozone tier would not be feasible for this project because of the extensive degree of research that would be required to define ecoregions and ecodistricts within each ecozone. However, in general, the USFWS ecosystem approach is compatible with the ecozones defined for Canada. This is attributed primarily to the similarities in the two approaches (e.g., both incorporate watershed factors). In addition, both systems were devised using international neighbors as stakeholders, which contributed significantly to similarities.

Freshwater habitats are not strongly emphasized in any of the reviewed approaches. However, the watershed approach adopted by the USFWS functionally addresses aquatic and semi-aquatic habitats without attempting to classify these as separate ecosystems. Given the widespread presence and variety of surface water bodies within Alaska, any further definition or classification of these habitats beyond this level would be of limited use for the purposes of this project. The USGS approach, which does not emphasize watershed criteria, results in single watersheds that cut across as many as seven ecoregions.

The USFWS ecosystem approach incorporates both habitat and wildlife usage in terrestrial and marine environments of Alaska. The ADFG approach is similar, but the focus is on a subset of harvested species, while the USFWS approach is more comprehensive because of its different objectives. With the exception of vegetation, which indirectly affects wildlife usage, the USGS approach does not address wildlife usage. This results in a more limited focus compared with the USFWS method, and results in a less robust approach relative to the goals of defining assessment endpoints by ecoregion.

Another important advantage of the USFWS approach lies in the broad-based participation of stakeholders, which contributed to a comprehensive approach to defining various ecological systems within Alaska and incorporating diverse cultural and societal considerations into the process.

17ECOREGION APPROACH FOR ECOLOGICAL RISK ASSESSMENTS FOR CONTAMINATED SITES IN ALASKA

Based on the criteria presented in Section B.1 and the review of the established approaches presented in Section B.2, the ecoregions defined by the USFWS ecosystem approach were selected, with slight modification, as a basis for developing default ecological assessment endpoints and indicator species. Specifically, the seven terrestrial ecoregions and the one terrestrial island/marine region defined by the USFWS approach were selected. The two marine regions, however, were combined with each terrestrial region that they abut.

The major strengths of this approach include, but are not limited to, the fact that the USFWS approach:

- Has been applied in Alaska.
- Incorporates abiotic, biotic (habitat and wildlife usage), and cultural factors.
- Comprehensively addresses terrestrial, aquatic, and marine habitat zones within Alaska.
- Addresses entire watersheds.
- Was developed with broad-based support from diverse stakeholders.
- Defines ecosystems that are manageable and concise in number, scale, and distribution.
- Is generally compatible with both the ADFG habitat management units and Canadian ecozones.
- Overall, is the most compatible with project goals.

The eight ecoregions selected are shown in Figure B.2-3 and include Aleutian Islands, Arctic Slope, Interior, Northwest, South-central, Southeast, Southwest, and Yukon-Kuskokwim Delta. Default assessment endpoints and indicator species were defined for each of these ecoregions.

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ATTACHMENT

STAKEHOLDERS INVOLVED IN DEVELOPING THE USFWS ECOSYSTEM APPROACH

19STATEWIDE ECOSYSTEM STAKEHOLDERS

Alaska Native Foundation
Alaska Federation of Natives
Alaska Native Brotherhood and Alaska Native Sisterhood
Alaska Trapper's Association
Alaska Native Brotherhood
Alaska Trophy Hunts
Alaska Wilderness Outfitters
Alaska Wildlife Alliance
The Honorable Ted Stevens
The Honorable Frank H. Murkowski
The Honorable Don Young
Alaska Resources Library, DOI
NMFS-SW Region
Environmental Quality Division – 774
Alaska Department of Fish and Game
Alaska Board of Fisheries
Alaska Board of Game
The Honorable Walter J. Hickel, Governor
Speaker of the House, Alaska State Legislature
Senate President, Alaska State Legislature
Alaska Center for the Environment
Alaska Conservation Foundation
Alaska Friends of the Earth
Alaska IMPACT
Alaska Indigenous Council
Alaska Lands Act Coordinating Committee
Alaska Legal Services Corporation
Alaska Natural Heritage Program
Alaska Outdoor Council
Alaska Waterfowl Association
Center for Urban Affairs and Policy Research
Citizens Advisory Commission on Federal Areas
Commonwealth North
Cooperative Park Studies Unit, University of Alaska Fairbanks
Greenpeace
International Association of Fish and Wildlife Agencies
Izaak Walton League
Kwik, Inc.
National Audubon Society
National Fish and Wildlife Foundation
National Wildlife Refuge Association
Alaska Natural Resources Center
Northern Alaska Environmental center
Northwest Outdoor Writers' Association
Rural CAP
Safari Club International
Sence, Inc.
Sierra Club
Sierra Club Legal Defense Find
The Nature Conservancy of Alaska
Trustees for Alaska
United Fishermen of Alaska
University of Alaska – Fairbanks
University of Alaska – Anchorage
University of Washington
Wilderness Society
Wildlife Federation of Alaska
Wildlife Legislative Fund of America
Wildlife Management Institute
U.S. Bureau of Land Management
National Park Service
Department of Defense

SOUTHEAST ECOSYSTEM

Sitka Subsistence Community
South Kuiu Thlingit Nation, Kuiu Island
Southeast Alaska Native Subsistence Commission
Sealaska Corporation

2SOUTHEAST ECOSYSTEM (cont.)

Shee Atika
Petersburg Indian Association
Ketchikan IRA Council
Ketchikan Indian Corporation
Huna Totem Heritage Foundation
Central Council of Tligit and Haida Indian Tribes
Chefornak Traditional Council
Organized Village of Kake
Organized Village of Saxman
Sitka Tribe of Alaska
Community Association of Angoon
Native Village of Chickaloon
Native Association of Yakutat
Indian Association of Hoonah
Chilkat Village of Klukwan
Chilkoot Indian Association of Haines
Community Association of Stebbins
Community Association of Craig
Cooperative Association of Kalwock
Cooperative Association of Hydaburg
Cooperative Association of Wrangell
University of Alaska – Sitka
Southeast Alaska Conservation Council
Southeast Alaska ANSCA Land Coalition
Sitka Community Association
Sitka Conservation Society
Sitka Sportsman
NPS – Glacier Bay National Park and Preserve
NPS – Klondike Gold Rush National Historical Park
NPS – Sitka National Historical Park
U.S. Forest Service – Admiralty National Monument
U.S. Forest Service – Tongass National Forest
Mayor – Ketchikan
Upper Lynn Canal Advisory Committee – Skagway
Wrangell Advisory Committee
Yakutat Advisory Committee
Alaska Reform
Government of Canada
Citizens' Advisory Commission on Federal Areas
Friends of Glacier Bay
Haines High School
Ketchikan Pulp Company
Lynn Canal Conservation Association
Russian Mission Schools
Angoon Advisory Committee
Edna Bay Advisory Committee
Elfin Cove Advisory Committee
Gastineau Channel Advisory Committee
Hydaburg Advisory Committee
Hyder Advisory Committee
Icy Straits Advisory Committee
Kake Advisory Committee
Ketchikan Advisory Committee
Klawock Advisory Committee
Klukwan Advisory Committee
Pelican Advisory Committee
Petersburg Advisory Committee
Port Alexander Advisory Committee

BERING SEA/ALEUTIAN ISLANDS ECOSYSTEM

Russian Government
Pribilof Aleut Fur Seal Commission
NANA Regional Corporation
Chevak Traditional Council
Bristol Bay Native Association
Calista Corporation
Cenaliulriit Coastal Management District
Azachorok, Inc.
Bering Straits Coastal Management Program
Bering Straits Native Corporation
Bristol Bay Coastal Resource Service Area Board
Association of Village Council Presidents
Arctic Slope Regional Corporation
Aleut Corporation
Aleutian Pribilof Islands Association
Alaska Eskimo Whaling Commission
Village Council of St. George Island
Tribal Council of Qawlingin

Qawalangin Tribe of Unalaska
Native Village of Diomede
Native Village of Akutan
Native Village of Gambell
Native Village of Atka
Aleut Community of St. Paul Island
NPS – Bering Land Bridge National Preserve
Alaska Legal Services Corporation
Alaska Sea Otter Commission
Bering Sea Fisherman's Association
Nunivak Island Guide Service
Central Kuskokwim Advisory Committee
Central Bering Sea Advisory Committee
Noatak Fish and Game Advisory Committee
Lower Yukon Advisory Committee
Lower Kuskokwim Advisory Committee
Chignik Advisory Committee
False Pass Advisory Committee
King Cove Advisory Committee
Kodiak Fish and Game Advisory Committee
Lake Illiamna Advisory Committee
Lower Bristol Bay Advisory Committee
Naknek/Kvichak Advisory Committee
Alaska Maritime National Wildlife Refuge
Togiak National Wildlife Refuge

Yukon Delta National Wildlife Refuge

Whittier Advisory Committee
Homer Advisory Committee
Kenai/Soldotna Advisory Committee
Matanuska Valley Advisory Committee
Mt. Yenlo Advisory Committee
Alaska Maritime National Wildlife Refuge
Kenai National Wildlife Refuge

Koniag, Inc.
Lake Illiamna Advisory Committee
Lower Bristol Bay Advisory Committee
Naknek/Kvichak Advisory Committee
Nelson Lagoon Advisory Committee
Nushagak Advisory Committee
Sand Point Advisory Committee
Togiak Advisory Committee
Unalaska/Dutch Harbor Advisory Committee
Alaska Maritime National Wildlife Refuge
Alaska Peninsula/Becharof National Wildlife Refuge
Izembek National Wildlife Refuge
Kodiak National Wildlife Refuge
Togiak National Wildlife Refuge

INTERIOR ECOSYSTEM

Yukon Tanana Subregion
Village Council of Northway
Tanana IRA Native Council
Native Village of Galena
Native Village Council – Koyukuk
Native Village Council – Ruby
McGrath, Takotna, Nikolai, Telida, Ltd.
Kuskokwim Corporation
Kuskokwim Native Association
Dinyee
Aniak Traditional Council
Inupiat Community of the Arctic Slope
Napakiak Village Council
Doyon, Limited

Dot Lake Village Council
Council of Athapaskan Tribal Governments
Calista Corporation
Cenaliulriit Coastal Management District
Azachorok, inc.
Bering Straits Native Corporation
Traditional Council of Arctic Village
Ahtna, Inc.
Village of Alatna
Village Council of Stevens Village
Village Council of Nondalton
Village of Aniak
Village of Holy Cross
Village of Chuathbaluk

Village of Allakaket
Village of Evansville
Village of Chalkyitsik
Village of Anaktuvuk Pass
Village Council of Tanacross
Village of Stoney River
Village Council of Eagle
Village of Crooked Creek
Village Council of Venetie
Village Council of Tetlin
Village of Manley Hot Springs
Village of Fort Yukon
Village of Birch Creek
Traditional Council of Arctic Village
Traditional Council of Red Devil
Organized Village of Grayling
Native Village of Rampart
Native Village of Sleetmute
Native Village of McGrath
Native Village of Ruby
Native Village of Minto
Native Village of Huslia
Native Association of Nenana
Native Village of Nikolai
Native Village of Hughes
Native Village of Koyukuk
Native Village of Beaver
Native Village of Circle
Native Village of Gulkana
Native Village of Napamute
Native Village of Lime Village
IRA Native Council of Tanana
Tok Shooters Association
NPS – Denali National Park and Preserve

YUKON KUSKOKWIM DELTA ECOSYSTEM

Nunakauiuk Yupik Corporation
Village of Chefornak
Village of Atmautluak
Village of Pitka's Point
Village of Brevig Mission
Village of Sheldon's Point
Village of Alakanuk
Traditional Council of Oscarville
Traditional Council of Pilot Station
Village Council of Umkumiut
Village of Scammon Bay
Village of Mountain Village
Native Village of Kasigullik
Native Village of Eek
Native Village of Russian Mission
Native Village of Tununok
Native Village of Marshall
Native Village of Algaaciq
Native Village of Kipnuk
Native Village of Kongiganak
Native Village of Hamilton
Native Village of Kotlik
Native Village of Ohogamiut
Native Village of St. Michael
Native Village of Nunapitchuk
Native Village of Napamute
Native Village of Emmonak
Native Village of Newtok
Native Village of Nightmute
Native Village of Kwigillingok
Native Village of Andreafsky
Middle Yukon Advisory Committee
McGrath Advisory Committee
Grayling/Anvik/Shageluk/Holycross Advisory Committee
Nunivak Island Guide Service
Central Kuskokwim Advisory Committee
Central Bering Sea Advisory Committee
Noatak Fish and Game Advisory Committee
Lower Yukon Advisory Committee
Lower Kuskokwim Advisory Committee
Native Village of Akiachak
Native Village of Savoonga
Native Village of Napakiak

YUKON KUSKOKWIM DELTA ECOSYSTEM (CONT.)

Native Village of Bill Moore's Slough
Native Village of Kaltag
Native Village of Kwinhagak
Native Community of Tuluksak
Native Village of Piamuit
Native Council of Orutsararmuit
Native Village of Nunivak
Native Village of Napaskiak
Native Village of Kalskag
Native Village of Mekoryuk
Association of Village Council Presidents
Azachorok, inc.
Bering Straits Coastal Management Program
Bering Straits Native Corporation
Bristol Bay Coastal Resource Service Area Board
Bristol Bay Native Association
Bristol Bay Native Corporation
Calista Corporation
Cenaliulriit Coastal Management District

BEAUFORT/CHUKCHI ECOSYSTEM

Government of Canada
Aleutian Pribilof Islands Association
Inupiat Community of the Arctic Slope
Napakiak Village Council
Kaktovik City Council
Kaktovik Inupiat Corporation
Inupiat Community of the Arctic Slope
Napakiak Village Council
Arctic Slope Regional Corporation
Alaska Eskimo Whaling Commission
North Slope Borough Fish and Game Advisory Committee
Alaska Legal Services Corporation
Eastern Arctic Advisory Committee
Kotzebue Advisory Committee
Lower Kobuk Advisory Committee
Noatak/Kivalina Advisory Committee
Northern Seward Peninsula Advisory Committee
Norton Sound Advisory Committee
Southern Norton Sound Advisory Committee
St. Lawrence Island Advisory Committee
Upper Kobuk Advisory Committee
Western Arctic Advisory Committee
Alaska Maritime National Wildlife Refuge
Arctic National Wildlife Refuge

NORTH PACIFIC/GULF OF ALASKA ECOSYSTEM

Sealaska Corporation
Huna Totem Heritage Foundation
Cook Inlet Region, Inc.
Copper River Native Association
Central Council of Tligit and Haida Indian Tribes
Chefornak Traditional Council
Bristol Bay Native Corporation
Cenaliulriit Coastal Management District
Bristol Bay Coastal Resource Service Area Board
Aleut Corporation
Aleutian Pribilof Islands Association
Ahtna, Inc.
Native Association of Yakutat
Native Village of Seldovia
United Cook Inlet Drift Association
Upper Lynn Canal Advisory Committee
Wrangell Advisory Committee
Yakutat Advisory Committee
Alaska Sea Otter Commission
Government of Canada
Prince William Sound Aquaculture Corporation
Prince William Sound Community College
Old Harbor School
Angoon Advisory Committee

Craig Advisory Committee
Edna Bay Advisory Committee
Elfin Cove Advisory Committee
Gastineau Channel Advisory Committee
Hydaburg Advisory Committee
Hyder Advisory Committee
Icy Straits Advisory Committee
Kake Advisory Committee
Ketchikan Advisory Committee
Klawock Advisory Committee
Pelican Advisory Committee
Petersburg Advisory Committee
Port Alexander Advisory Committee
Saxman Advisory Committee
Sitka Advisory Committee
Sumner Strait Advisory Committee
Tenakee Springs Advisory Committee
Alaska Maritime National Wildlife Refuge
NPS – Kenai Fjords National Park

APPENDIX C

DESCRIPTIONS OF ECOLOGICAL SUBREGIONS

TABLE OF CONTENTS

Page

TABLE

Table No.

LIST OF FIGURES

Figure No.

ABBREVIATIONS AND ACRONYMS

cm	centimeters
ºC	degrees Centigrade
DOI	U.S. Department of the Interior
ERA	ecological risk assessment, 1
km^2	square kilometers
m	meters

APPENDIX C

DESCRIPTIONS OF ECOLOGICAL SUBREGIONS

APPENDIX C

DESCRIPTION OF ECOLOGICAL SUBREGIONS

20INTRODUCTION

The eight ecoregions selected for use in ecological risk assessment (ERA) guidance in Alaska include Aleutian Islands, Arctic Slope, Interior, Northwest, Southeast, Southcentral, Southwest, and Yukon-Kuskokwim Delta. Ecoregion boundaries are depicted in Figure C.1-1, and general ecoregion descriptions are provided in Section 3.0 of the Technical Background Document. To supplement these ecoregion descriptions, subregions are described in this appendix. These 29 subregions, primarily taken from Gallant et al. (1995) and based on the major vegetation types found in Alaska, are also shown in Figure C.1-2. Because watersheds define the eight major ecoregions and vegetation types delineate the 29 ecological subregions, the boundaries of the two do not coincide. Therefore, a single ecoregion may encompass several subregions, and one subregion may be found in two or more ecoregions. Table C.1-1 shows the correlation between ecoregions and subregions.

21AHKLUN AND KILBUCK MOUNTAINS

The Ahklun and Kilbuck Mountains subregion is defined to the west and south by the upper Anick River watershed, and to the east and north by forested lowlands. The mountains are steep, rising abruptly to 1,500 m, and are separated by broad valleys. Glaciers are small in the Kilbuck Mountains because of the relatively low elevations. Permafrost is found at isolated locations in the subregion.

The Kilbuck Mountains are primarily underlain by deformed sedimentary and volcanic rock of Paleozoic and Mesozoic age. Most streams are small and incised in bedrock. Some long, narrow lakes occupy the U-shaped valleys. Soils of the subregion include Histic Pergelic Cryaquepts, Pergelic Cryaquepts, Typic Cryochrepts, Lithic Cryumbrepts, Pergelic Cryumbrepts, Pergelic Cryorthods, Typic Haplacryods, and Typic Humicryods (Gallant et al., 1995). Valley soils are developed glacial till and alluvium, and mountain soils are poorly developed gravelly colluvium.

The climate of the Kilbuck Mountains is transitional between maritime and continental. The maritime effects from the Bering Sea to the southwest are buffered by the Ahklun Mountains and the southern portions of the Kilbuck Mountains. Average daily temperatures range from –16°C to 19°C. Temperatures generally tend to decrease with increasing elevation. Mean annual precipitation varies from 100 to 200 cm (increasing with elevation), with up to 510 cm of snow (Gallant et al., 1995).

The upper elevations of the Kilbuck Mountains are comprised of barren rocky slopes. The highest elevation vegetation begins with lichens and dwarf scrub-shrub. This community transitions into dwarf scrub-shrub with mountain avens, mosses, low-lying berries, and dwarf birch, which cover a majority of the valley bottoms. Some of the valley bottoms include wet meadow conditions with Labrador tea, sedges, and mosses. Drier areas, such as high banks of lakes and streams and well-drained floodplains, support tall scrub species including willow, alder, and dwarf birch. Some of the richest valley bottoms may support forests of spruce, balsam poplar, and paper birch with a berry and prickly rose understory, and an herb layer of twinflower, bluejoint, horsetail, mosses, and lichens. The valleys are transitional areas from the mountains to the interior lowlands (Gallant et al., 1995).

Invertebrates are few in the mountainous climate of the Kilbuck Mountains because of wind, weather conditions, and physiography. Within the wetter valley habitats, the species present are expected to include mosquitoes, flies, sawflies, leafhoppers, leaf beetles, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Aquatic invertebrates of the few lakes may include copepods, rotifers, or cladocerans. The primary benthic invertebrates are likely to be chironomids, but dipterans, oligochaetes, steroptera, coleoptera and gastropoda may also occur (U.S. Navy, 1977; Holmquist, 1975; and Hobbie, 1973). Some tributaries of the upper reaches of the Anick River are likely to support anadromous species such as salmon or steelhead. Resident species, including northern pike, rainbow trout, grayling, whitefish, sucker, inconnu (sheefish), burbot, and stickleback are also likely to be present.

The birds of the Kilbuck Mountains are generally limited to the valleys. The diversity of passerine species increases with increasing distance from the highest peaks; eventually, the Kilbuck Mountain bird community blends with that of the interior lowlands. Wheatear, water pipit, ptarmigan, and raven are the species inhabiting the higher elevations; robins, thrushes, warblers, jays, sparrows, and woodpeckers may inhabit the forested valley floors. Hawks and owls also may be found in the forested habitats.

The lack of ground cover at high elevations limits the numbers of mammals. However, within the valleys, shrews, voles, and lemmings may be present; these prey items may support coyotes, foxes, and wolves. Marmots and hares may inhabit rocky substrates. Caribou may be found seasonally in the mountain valleys. Moose are uncommon in the subregion, but are possible in the lower stretches of the wettest valleys. Dall sheep are possible inhabitants of the Kilbuck Mountains, but are not numerous.

22ALASKA PENINSULA MOUNTAINS

A southern extension of the Alaska Range, the Alaska Peninsula Mountains, extend the length of the Alaska Peninsula and include the majority of Kodiak Island. This subregion is defined to the west by the Bristol Bay-Nushagak Lowlands, to the south and east by the Gulf of Alaska, and to the north by the Alaska Range. The mountains are rounded, folded, and faulted sedimentary ridges, with occasional volcanic peaks rising to 1,200 m. Glaciers are found at higher elevations, and many features of glacial erosion are present from both recent and Pleistocene glaciation. The mountains are dissected by many glacier-fed short, steep waterways. The streams slow and meander as they reach the Bering Sea or Gulf of Alaska. Little or no permafrost is found in the subregion.

The mountains are composed of stratified Jurassic, Cretaceous, and Tertiary sedimentary rocks and Quaternary volcanic rock. Dominant soils include Typic Haplocryands and Typic Vitricryands (Gallant et al., 1995). Valley soils are volcanic ash and cinder resulting from glacial till. Mountain peaks have little or no soil.

The climate of the Alaska Peninsula Mountains is predominantly maritime with high precipitation and small diurnal temperature fluctuations. Mean annual precipitation varies from 60 to 330 cm, with 55 to 510 cm of snow (Gallant et al., 1995). Average daily temperatures range from –1°C to 15°C, varying with elevation.

The upper elevations of the volcanic mountain peaks are barren, rocky slopes. The vegetation at the highest elevation is dwarf scrub-shrub community dominated by crowberry. Other species in this community include other berries, mountain avens, willows, and mosses. With decreasing elevation, this community transitions to a low scrub-shrub community with willow, birch, berries, Labrador tea, short grasses, and mosses, and eventually to tall scrub and broadleaf forests on the protected, low elevation slopes and in valley bottoms. The tall scrub and broadleaf forests include alder, willow, poplar, bluejoint, and mosses. Some of the valley bottoms include low scrub bogs and grassy meadow conditions with crowberry, Labrador tea, cranberry, blueberry, cinquefoil, buckbean, sedges, bluejoint, and mosses (Gallant et al., 1995). The richer, more diverse valleys are a transition area to the Bristol Bay-Nushagak Lowlands to the northwest or lead southeast to the Gulf of Alaska.

No information was found regarding the specific invertebrates. Invertebrate species are expected to be few in the mountainous areas because of wind, weather conditions, and physiography. Mosquitoes, gnats, and blackflies are likely to be abundant in the valleys. Other likely taxa include diptera, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, and lepidoptera. The predominant taxa in typical central Alaskan streams include stoneflies, mayflies, and dipterans (Brown, 1987; and Clay, 1973). These species are likely to be present in Alaska Peninsula streams, rivers, and lakes.

A large diversity of birds inhabits this subregion because of the variable habitat from mountain peaks to coastal shorelines and the relatively mild climate. The birds that occupy the mountainous areas generally are limited to valleys where berries, seeds, and prey are present in greater numbers than at higher elevations. The diversity of passerine species increases with increasing distance from the highest peaks, eventually blending with that of the lowlands or coast. Wheatear, water pipit, ptarmigan, and raven are the species inhabiting the higher altitudes,

Comment: Rone—Huh? Clarify.

and shrikes, grosbeaks, longspur, snow bunting, robins, warblers, and sparrows may inhabit the forested valley floors. Bald eagles, rough-legged hawks, short-eared owls, and other raptors also may be found in the forested habitats. Waterfowl (mallard, pintail, teal, and others) and shorebirds (plovers, sandpipers, and phalaropes) may seasonally inhabit the low elevation lakes and ponds, and mergansers may be found nesting along some of the alpine rivers. Ptarmigan and grouse also are common.

The lack of ground cover at high altitudes limits the numbers of mammals. Dall sheep are possible inhabitants of the mountainous areas, but are not numerous. However, within the valleys, shrews, voles, and lemmings may be present; these prey items may support coyotes, foxes, and wolves. Marmots, pika, and hares may inhabit rocky substrates at the bases of mountain slopes. Caribou may be found seasonally in the mountain valleys. Moose are uncommon in the subregion, but are possible in the lower stretches of the wettest valleys.

There are likely few or no fish in the highest reaches of the steep streams of the mountains. However, there are many lower elevation gravelly riverbeds that provide optimal spawning grounds for abundant anadromous species. These include salmon, (chinook, coho, sockeye, pink, and chum); Dolly Varden; rainbow trout; grayling; pike; and whitefish. The few lakes of the region may also support significant resident populations of rainbow trout, sculpins, and stickleback, among other species.

23ALASKA RANGE

Elevations within the Alaska Range extend from extremes of near sea level in the valley floors to a maximum of 6,100 m at the crest of Mt. McKinley, with most of the area between 600 to 3,900 m. The terrain is very rugged with deep, broad valleys and steep (>25 degrees) barren mountainsides. Glaciers covered the mountains in the Pleistocene and are still present at higher elevations. Permafrost is discontinuous under the subregion.

The Alaska Range is underlain by Cretaceous, Paleozoic, and Precambrian bedrock. While much of the subregion consists of rocky slopes, ice fields, and glaciers, some soils have developed and include Lithic Cryorthents, Pergelic Cryaquepts, Pergelic Ruptic-Histic Cryaquepts, Typic Cryochrepts, Pergelic Cryumbrepts, and Typic Cryumbrepts (Gallant et al., 1995). Hillside soils are gravelly, well drained, and shallow. Valley soils are poorly drained, gravelly alluvium or silty colluvium.

The climate of the Alaska Range is mainly influenced by continental factors. Average temperatures range from –25°C to 18°C. Temperatures generally decrease with elevation, but this trend is variable given winds and terrain. Mean annual precipitation is approximately 38 cm, including 150 to 305 cm of snowfall (Gallant et al., 1995). Higher elevations may receive as much as 1,000 cm of precipitation.

A majority of the Alaska Range is devoid of vegetation because of its high elevations and harsh climate. Dwarf scrub-shrub communities are the most common vegetation. Some wet or moist sites such as valleys and lower hillslopes support taller scrub and open needleleaf forests. Dwarf scrub-shrub species include mountain avens, berries, and cassiope. Sedges or alpine holygrass may also be present with oxytrope, sweet-vetch, mosses, and lichens. Taller scrub-shrub species include birch, alder, and willows, with berries, fescue grass, coltsfoot, and wormwood. The wettest areas may also support Labrador tea and bog blueberry (Gallant et al., 1995).

No information was found regarding the invertebrates that occupy the Alaska Range. Generally, invertebrates are scarce in harsh mountainous climates. A few species are known to inhabit snowfields and may be present in this subregion. Within the low-lying and moist habitats, mosquitoes, flies, and other species may be present. Aquatic invertebrates may be present in the valley rivers and streams.

Most birds found in the Alaska Range are limited to lower elevations. With increasing distance southward and corresponding increases in elevation, the diversity and abundance decrease dramatically. Passerine species (song and perching birds) might include wheatear, water pipit, ptarmigan, and raven, because these species are able to inhabit harsh environments. Some hawks also may be found nesting in the moderate altitude cliffs where prey is available on the valley floor.

The lack of ground cover limits the numbers of small mammals. This, in turn, limits larger predatory mammals. At lower elevations, shrews, voles, and lemmings may be present. However, at higher elevations, small to medium-size mammals may be limited to the Alaska vole, marmot, pika, and hares, all of which may inhabit rocky substrates. Caribou and moose are unlikely in all but the lowest elevations of this mountainous subregion. Dall sheep may be present in the mountains but are not numerous. Larger mammalian carnivores such as wolves may be found in the mountains, but usually only in the vicinity of Dall sheep, moose, or caribou.

Some tributaries of the upper reaches of the Tanana River pass through the Alaska Range. These tributaries are likely to support anadromous species such as salmon. Resident species, including northern pike, grayling, whitefish, sucker, inconnu (sheefish), burbot, and stickleback, are also likely.

24ALEUTIAN ISLANDS

The Aleutian Islands include 12,000 km^2 of volcanic islands in the southern Bering Sea. Elevations range from sea level to 1,900 m. The higher volcanoes are capped by snow and ice, and the islands have been extensively glaciated. The islands are free from permafrost, and the rivers are short, fast flowing and commonly ephemeral. Lakes are uncommon on most of the islands, but they are sometimes present within volcanic craters (Gallant et al., 1995).

Soils are generally thin, formed from volcanic ash or cinders. Some organic soils have developed in valley bottoms and other bowl-shaped features. Soil types include Typic Haplocryands and Typic Vitricryands.

The climate of the Aleutians is maritime with four months of frost-free weather (May to September). Precipitation varies greatly from 53 cm to 208 cm. Average daily temperatures are very consistent, ranging from –7°C in winter to 13°C in summer. Temperature variation for some islands may be as little as 9°C throughout the year. Fog is common on many of the islands.

Relatively few plant taxa inhabit the Aleutian Islands. Low shrubs, grasses, and forbs dominate the treeless islands. Wet meadows and marshes cover approximately 10 percent of the land surface. The upper elevations of volcanic cones are barren and windswept with consistent snow cover. Downward at more moderate elevations, lichens, dwarf willow scrub, and crowberry scrub communities tend to be present. These may include species such as mountain avens, Labrador tea, mosses, cassiope, berries, and spirea. At lower elevations, moist grassland communities become dominant. Bluejoint, sedges, fireweed, and horsetail are common in the moist grasslands. Along drier coastal ridges, hair-grasses provide the dominant cover. Some wetland/bog areas are also present on the islands. These communities include berries, bog-rosemary, Labrador tea, sedges, club rush, and mosses. Aquatic plants may include mosses, liverworts, buttercup, millfoil, marigold, mare’s tail, horsetail, starwort, rushes, sedges, pondweed, bur reed, quillwort, and algae.

The freshwater macroinvertebrates of the Aleutians are not diverse. They may include annelids, nematodes, mollusks, and arthropods. Mollusks known to inhabit some islands include small and medium sized clams. Insects and crustaceans are the most common arthropods, and these two orders are the most abundant Aleutian macroinvertebrates. *Hyallela* species are commonly found in small streams of the islands, and isopods, mysids, and other amphipods also may be present. Some islands have no mosquitoes, but have other insects such as mayflies, caddis-flies, blackflies, water boatmen, and beetles.

Birds are the dominant fauna on the Aleutian Islands. Some islands have up to 50,000 birds. However, there are usually only a few species that make up a majority of the birds on any given island. The habitat differences on each island dictate which species are dominant. Generally, seabirds, waterfowl, and shorebirds are common, but certain passerines such as the longspur are often the most numerous on islands with significant amounts of meadow/tundra habitats. Common seabirds, waterfowl, and shorebirds may include puffins, cormorants, guillemots, loons, gulls, terns, eiders, teal, mallard, pintail, sandpipers, and phalaropes. Typical passerine species may include longspurs, snow buntings, finches, winter wren, and sparrows. A few birds of prey such as bald eagles, jeagers, and peregrine falcons are also found inhabiting the islands.

The only terrestrial mammals, which are found on only some of the islands, are introduced caribou, Norway rat, and fox. Caribou were introduced to and currently inhabit Adak Island.

Freshwater fishes of the island include stickleback, sculpins, and Dolly Varden. Anadromous fish such as salmon may also spawn in island streams. No amphibians or reptiles inhabit the Aleutian Islands.

25ARCTIC COASTAL PLAIN

The Arctic Coastal Plain covers approximately 50,000 km^2 within the northern third of the Arctic Slope ecoregion and extends nearly 100 miles inland from the town of Barrow. The plain becomes continually narrower both east and west of Barrow and reaches from just south of Point Lay (Naokak) east to Kaktovik. The elevation of the plain ranges from sea level to approximately 175 m at the base of the Arctic Foothills. The terrain is very flat with thousands of thaw lakes ranging from a few meters to 15 km in length. Small, irregularly-shaped wetland “polygons” are also common, formed by ice wedges sinking or being pushed up by freeze-thaw cycles of the region.

The climate of the plain is typical of arctic regions with very cold average temperatures (–30°C to 8°C), strong and persistent winds, and frequent cloud cover and/or fog. Average annual precipitation is approximately 14 cm with 30 to 75 cm of snowfall (Gallant et al., 1995).

Siltstone and sandstone underlie the Arctic Coastal Plain, with an overlay of Quaternary deposits of alluvial, glacial, and aeolian origin. In order of predominance, soils include Histic Pergelic Cryaquepts, Pergelic Cryaquepts, peats, Pergelic Cryopsamments, and loams (east of the Colville River) (Gallant et al., 1995). Gravels and sands are frequently found in active and abandoned riverbeds, and active sand dunes occur locally.

Vegetation within the coastal plain varies with slight changes in soil moisture regimes. Wet graminoid (grassy) meadows are dominant in the low-lying, wetter soil conditions. The dominant plant species in wet meadows are sedges. Cottongrass, tundra grass, mosses, horsetails, and rushes also occur. At slightly higher elevations (frequently only a few centimeters higher) where the soils are dryer, cottongrass or tundra grass tends to be dominant, followed by sedges. On drier areas such as rivers, streams, and shorelines of lakes, as well as on pingos (mounds created by frost heaving), dwarf shrub communities may develop. The meadow communities frequently are not distinct, intertwining across the entire subregion in correspondence with microtopographic relief. The vegetation communities are very low lying (<25 cm), providing the open expanse of this subregion. Within the many thaw lakes, planktonic; submergent (pondweed, bur reed, and buttercup) and emergent species (pendant grass); floating vegetation; and bottom algae may be present (Holmquist, 1975).

Invertebrates, wildlife, and fish inhabiting the Arctic Coastal Plain are well suited to the extreme weather conditions, and many are migratory to avoid the harsh winters. The diversity of species is limited by arctic conditions; however, the abundance of particularly well-adapted species may be high. This is especially true for a few terrestrial invertebrate species that are critically important in the arctic food web. The most abundant invertebrates include flies such as the crane fly. The peak hatches of adult crane flies occur shortly after the spring thaw. Other frequently found invertebrates include sawflies, leafhoppers, and leaf beetles. Various species of trichoptera, coleoptera, hemiptera, and arachnids also inhabit the Arctic (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Aquatic invertebrates of the lakes and ponds include copepods, rotifers, and cladocerans. The primary benthic invertebrates are chironomids, but dipterans, oligochaetes, steroptera, coleoptera, and gastropoda also occur (U.S. Navy, 1977; Holmquist, 1975; and Hobbie, 1973).

Birds and mammals found in the Arctic Coastal Plain include herbivores, omnivores, and carnivores. Common passerine species (song and perching birds) include Lapland longspurs, redpolls, and snow buntings. These species are usually omnivorous, with diets dependent on the availability of food items. The most common arctic birds are shorebirds and waterfowl. Many of these species commonly nest in coastal wetlands and wet meadows throughout the region. Pintail, plover, phalarope, gulls, and sandpipers are the most common species (Kessel and Cade, 1958; and Pitelka, 1974). However, many other species are found in large numbers throughout the subregion, including a significant concentration of Brant that molt annually on Teshekpuk Lake, west of the Colville River delta. Ptarmigan are the only gallinaceous birds found on the Arctic Coastal Plain and are year-round residents. Other resident birds include redpolls and snowy owls.

Common small mammals include shrews, voles, and lemmings. These resident species are critical to the ecosystem as prey items. Lemmings may be the most important mammals on the coastal plain because several predators (mammals and birds) depend on them as prey. In years when there are cyclical declines in the number of lemmings, many foxes must switch to young birds and eggs as a dietary mainstay. Foxes may be found on the coastal plain all year. Caribou are the most abundant large mammal of the coastal plain, migrating north in the spring and south in the fall. The three major caribou herds include the western, central, and Porcupine. Musk-ox, moose, wolves, and grizzly bears are also found in limited numbers across the Arctic Coastal Plain.

Fish, such as Arctic grayling, salmon (pink and chum), char, cisco, stickleback, whitefish, sculpin and sucker, are found in larger lakes or rivers, although salmon are not common and may be limited to the western portion of the plain, including the Colville River (U.S. Department of the Interior [DOI], 1979; U.S. Navy, 1977; and Craig and McCart, 1974). Anadromous fish are most common and include char, cisco, and whitefish. Their migration is dependent on the freeze-thaw cycles of the rivers and bays of the subregion. Most of the lakes and ponds in the Arctic Coastal Plain are less than 2 m deep, freezing solid in winter. Water quality is usually poor with low nitrogen and oxygen content, limiting fish populations to rivers and the deepest lakes. Wood frogs inhabit some areas of the Arctic Coastal Plain. No reptiles are found in this subregion.

26ARCTIC COASTLINE/ESTUARY

Beach ridges and barrier islands provide the Arctic Coastline habitat. The coastline is distinctly different from the wet meadows and thaw lakes that dominate much of the remainder of the Arctic ecoregion. Coastline habitat extends from the ocean side of the barrier islands, landward to the ridges, bluffs, and cliffs along the mainland coast. The beaches and islands are formed by winds, waves, tides, storm surges, ice movement, and river discharge in combination with water circulation, coastal soil erosion, and sediment transport and depositional patterns. The majority of beaches and barrier islands are composed of coarse sands and gravels. The only vegetated soils are on the tops of bluffs and a few of the larger, stable islands.

The barrier islands also frequently define the outer edge of estuarine environments (bays, lagoons, and river deltas), and the coastline plant, invertebrate, fish, and wildlife community is integrally linked to estuaries of the Beaufort and Chukchi Seas (Arctic Ocean). Arctic estuaries are generally small, given the low tidal fluctuations (<35 cm) and rapid mixing of fresh and saline waters that result from the persistent winds of the region. However, they are important biological centers, providing resting, rearing, feeding, and migration staging grounds for many of the fish, waterfowl, and shorebirds of the Arctic.

The amount of exposure to ice and wave action, the type of soil/sediment, and salinity mainly determine the presence of vegetation in the coastline community. Plants found within the terrestrial coastline community include alkali grass, sedges, grasses on beaches, and dwarf shrubs on beach bluffs and on well-established barrier islands. Phytoplankton (nanoplankton) and algal species may also be found in the estuaries. The plants within the coastline community play a critical role in support of the millions of migratory shorebirds and waterfowl that arrive in the Arctic each spring.

Invertebrates occupying the estuaries include pelecypods, priapulids, polychaetes, tunicates, isopods, mysids, and amphipods. Zooplankton, such as cladocerans and copepods, are also present. These few species provide a critical production and decomposition role within the estuarine ecosystem and serve as the food base for many higher trophic-level species.

Birds found within the coastline community are a subset of those found in the Arctic Coastal Plain. Migratory species arrive in late April and May, spreading eastward until reaching their favored nesting grounds. Nesting and rearing occur in June and July, and the birds depart for warmer climes by early to mid-September. Migratory birds primarily include shorebirds, water-fowl (especially sea ducks such as the eider and harlequin), and sea birds such as kittiwake, gulls, and guillemots. A greater diversity of bird life can be found on the Chukchi Sea than the Beaufort Sea. This is because of the relatively milder climatic conditions toward the west, and the presence of higher bluffs and cliffs along the beaches that are used as nesting sites.

Mammalian use of the coastline habitats is seasonal, depending on the presence of pack ice and snow cover. Species inhabiting this area include polar bears, caribou, foxes, ground squirrels, seals, and walrus. Polar bears are present on the coastline only in the winter when pack ice reaches the shore. The presence of foxes in the coastline community depends on the seasonal abundance of lemmings; when lemming numbers decline, foxes move to the coastline to prey on young birds. Caribou are migratory within the coastline and coastal plain communities, arriving in the late spring and leaving in late summer. There are limited numbers of small mammals within the coastline habitats. Where soil conditions allow burrowing, small mammal populations of voles or lemmings may develop in shoreline areas. However, the sandy conditions generally do not support burrows, so the small mammals primarily remain farther inland. Marine mammal use of the coastline is primarily for feeding and haulout.

Many of the fish within the estuaries are also subject to seasonal environmental influences. Marine, anadromous, and freshwater species may be present at any given time. Species frequently found within the coastal Arctic estuaries include cisco, char, sculpin, and cod. Other species such as whitefish, flounder, herring, and grayling may be present.

27ARCTIC FOOTHILLS

The Arctic Foothills range from the U.S.-Canada border east to the Chukchi Sea. They are bounded to the north by the Arctic Coastal Plain and to the south by the Brooks Range. The elevation of the foothills ranges from 175 to 800 m. The terrain is gently rolling, with plateaus and valleys gently rising toward the south.

The climate of the Arctic Foothills is similar to the Arctic Coastal Plain, but somewhat warmer in winter. Records of average daily temperatures (–29°C in winter to 15°C in summer) and precipitation (14 cm) are not well-documented for this subregion (Gallant et al., 1995). Freezing temperatures may occur year-around, but July and August are usually frost free. More precipitation may fall on the southern portions of the subregion because clouds accumulate against the Brooks Range. In addition, the precipitation in this area is more likely to fall as snow because of the higher elevations.

The northern portions of the foothills are broad, rounded, east-west ridges with mesas underlain by Quaternary glacial, alluvial, and aeolian materials that overlie Lower Cretaceous sedimentary bedrock (Gallant et al., 1995). This portion of the subregion is generally at an elevation of less than 600 m. The southern section has alluvial and colluvial deposits overlying Jurassic and early Cretaceous bedrock largely comprised of graywacke and chert formations. The southern hills are at a higher elevation (<800 m), have more irregular peaks and valleys and long linear ridges, and are more rugged toward the Brooks Range. Soils include Histic Pergelic Cryaquepts, Pergelic Cryaquepts, Pergelic Ruptic-Histic Cryaquepts containing silty or loamy colluvial sediments in the valleys, and gravelly eroded rock on hills and ridges (Gallant et al., 1995). These soils are either acidic mineral or organic peaty types.

Generally, vegetation of the Arctic Foothills is mesic (moist) graminoid herbaceous (grassy tundra) and dwarf scrub. In the northern portions, wet meadows are more frequent, similar to those in the Arctic Coastal Plain. Proceeding southward, there is a transition from wet meadows to a moist upland community as elevation increases and drainage improves. Grasses and sedges are dominant on most of the rolling hills of the subregion. In the drier areas, tussock-forming grasses and low shrubs, such as dwarf arctic birch and crowberry, are the most common species. The elevated banks of the myriad of drainages, streams, and rivers are dominated by the scrub-shrub community. Mosses and lichens are also common throughout the subregion. As with the Arctic Coastal Plain, the general lack of tall shrubs and trees provides an open expanse across the entire area. Some taller shrubs, especially willow and alder, up to 2 to 3 m high may occur in river drainages and floodplains.

The invertebrate and wildlife species inhabiting the Arctic Foothills subregion are similar to those of the Arctic Coastal Plain. However, the presence of drier vegetative communities, in addition to the wet meadows, and stream/river influences provide for greater diversity. Invertebrates may include the dominant craneflies, muscids, and chironomids, but may also include other flies, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). In rivers and streams, trichoptera, ephemeroptera, plecoptera, and chironomids are the most common species (Selkregg, 1975).

The most common bird species encountered include the Savannah sparrow, jaegers, phalaropes, snipe, teal, and pintail (Pitelka, 1974; and Kessel and Cade, 1958). Many passerine species migrate to the foothills subregion, taking advantage of the drier uplands and scrub-shrub habitat. Waterfowl tend to be less abundant in the foothills because of the decreased presence of wet meadows, lakes, and ponds. However, ptarmigan are more abundant, especially in shrub-brush habitat along rivers and streams. Raptors are common foragers in the foothills. The gyrfalcon, rough-legged hawk, and peregrine falcon are the most common. Migrating raptors arrive in mid-April, and nestlings are fledging in concert with other bird species that serve as prey. Resident species include redpolls, ptarmigan, raven, and gyrfalcon.

While occurrences of mammals are similar in the Arctic Foothills and Arctic Coastal Plain, ermine and gray wolves are commonly found in the former and not in the latter (Bee and Hall, 1956; Pruitt, 1966; Lent, 1966; and U.S. DOI, 1979). In addition, lemming populations differ between these areas with more collared lemmings than brown lemmings, and there are more species of shrews and voles in the foothills than are found in the Arctic Coastal Plain. The arctic hare also is found in the moist uplands of the foothills subregion (Manville and Young, 1965; Rausch, 1951 and 1953; Bee and Hall, 1956; and Ernest, 1971). Caribou are common across the foothills, and moose are found occasionally in wet meadows of the subregion. Carnivorous mammals such as ermine, weasel, wolverine, red fox, and gray wolf inhabit the foothills, and their population densities usually reflect those of their respective preferred prey items. Common resident mammals include shrews, voles, lemmings, hares, weasels, ermine, foxes, wolves, and wolverine.

The increased wildlife diversity in the foothills versus that of the coastal plain is a direct reflection of the increase in varying habitats. These different habitats are a reflection of the soil moisture regimes and soil types found in the foothills. They provide food and cover that are not found on the plain, resulting in the success of herbivorous species, especially small mammals that do not inhabit the Arctic Coastal Plain. The resulting increase in resident small mammals (prey) is directly reflected by an increase in resident carnivorous mammals and birds (predators).

Fish are rare in this subregion but include char, grayling, lake trout, and stickleback. These fish occur only in the large rivers and deepest lakes and ponds.

28ARCTIC OCEAN (BEAUFORT AND CHUKCHI SEAS)

The Arctic Ocean subregion is bounded by the Bering Strait and the Arctic Coast of Alaska to the south, the United States-Russia Convention Line of 1867 on the west, the Arctic to the north, and the U.S.-Canada border on the east. The dominant physical characteristic of the subregion is the presence of pack ice for most of the year. The climate is characterized by long, cold winters and short, cool summers. There are 24 hours of daylight in June and 24 hours of darkness in December.

Invertebrates of the Arctic Ocean are not diverse, but may be abundant depending on ocean floor characteristics and depth (MacGinitie, 1955). Species may include pelecypods, priapulids, polychaetes, tunicates, isopods, mysids, and amphipods.

Marine macrophyte species are very limited, but phytoplankton such as Chrysophyta and Cryptophyta (Horner, 1969) are abundant during certain periods and provide critical forage for whales and other species.

While intertidal areas are often some of the most biologically productive habitats, the small Arctic tidal fluctuations (<35 cm) limit the amount of tide flats that are exposed during low tide. This limits the productivity of the Arctic intertidal areas in comparison with more temperate regions that have larger diurnal tidal fluctuations. A description of the nearshore/estuarine environment is provided under the description for the Arctic Coastline subregion.

All of the birds of the Arctic Ocean are dependent on the estuaries, lagoons, shoreline, or Arctic Coastal Plain. Therefore, they are discussed within the descriptions of the Arctic Coastline and Arctic Coastal Plain subregions.

Many mammals of the region depend on pack ice; these include ice-inhabiting pinnipeds such as walrus, ringed seals, bearded seals, and polar bears. Other marine mammals include beluga, gray, and bowhead whales that are frequently present in the waters off the northern coast of Alaska.

Common fish within the Arctic Ocean include cod (arctic and saffron), capelin, starry flounder, arctic char, arctic grayling, pink salmon, and chum salmon. Each of these species is migratory; they retreat to deeper, warmer, or flowing waters during the winter when ice covers the ocean.

29BERING SEA

Continental shelf waters in this subregion are extremely productive, supporting a rich diversity and high biomass of plankton, shellfish, fish, seabirds, and marine mammals. Phytoplankton, such as Chrysophyta and Cryptophyta, are abundant and provide irreplaceable forage for whales and other species. Marine algae species play an important role in the food chain of bird and fish species inhabiting the islands and nearshore areas. The algae are present at various depths and are associated with bottom structures. There are over 100 species of algae within at least three taxonomic groups, including Chlorophycophyta, Phaeophycophyta, and Rhodophycophyta (Lebednik and Palmisano, 1977).

Invertebrates of the Bering Sea are diverse and abundant. One hundred and forty-two species were found to inhabit the waters surrounding Amchitka Island (O'Clair, 1977). Among these, polycheates, gammarids, and gastropods were the most abundant. Shellfish include abalone, king crab, tanner crabs, razor clams, and shrimp. Barnacles, snails, limpets, and starfish also are common. Other species include representatives of Porifera (sponges); Cnidaria (hydrozoans); Ctenophora (comb jellies); Platyhelminthes (flatworms); Nemertea (ribbon worms); Mollusca (gastropods, bivalves, and cephalopods); Annelida (segmented worms); Sipuncula (peanut worms); Arthropoda (barnacles, shrimp, and crabs); Bryozoa (moss animals); Brachiopoda (lamp shells); Phoronida (phoronids); Echinodermata (echinoids, crinoids, etc.); and Chordata (thaliaceans and allies) (Barr and Barr, 1983). Descriptions of nearshore/estuarine environments are provided in the descriptions for the following subregions: Northwest Coastline/Estuary, Yukon-Kuskokwim Delta Coastline/Estuary, and Southwest Coastline/Estuary.

Fish of the Bering Sea include all major salmon species, cod (arctic and saffron), capelin, arctic char, Dolly Varden, steelhead, lingcod, halibut, rockfish, herring, and eulachon. Many of these species are migratory in some fashion, some returning to rivers to spawn and others retreating to deeper, warmer, or flowing waters during the winter when ice covers the sea. Other common species include perch, sablefish, pollock, sole, flounder, lampreys, sharks, skates, smelts, lightfishes, viperfishes, lances, grenadier, sandfishes, ronquils, pricklebacks, poachers, and others (Barr and Barr, 1983).

Most of the seabirds of the Bering Sea are associated with coastline cliffs and shorelines of the mainland and numerous Bering Sea islands. These shore-dependent birds use the open water to varying degrees, some staying close to shore and others spending a great deal of time out to sea. These species include fulmar, shearwaters, storm petrels, cormorants, gulls, terns, kittiwakes, murres, guillemots, murrelets, auklets, and puffins. Three species of albatross (including the endangered short-tailed albatross) inhabit the skies above the Bering Sea and rarely touch down on land.

Several marine mammals are associated with the pack ice. These include polar bears (in the far northern Bering Sea), walrus, seals, sea lions, and sea otters. Beluga, gray, bowhead, blue, humpback, sei, finback, sperm, little piked, beaked, right, pilot, and orca whales also are frequently found in the waters off the northern coast of Alaska. Other marine mammals found in the Bering Sea include porpoises.

30 BRISTOL BAY-NUSHAGAK LOWLANDS

The Bristol Bay-Nushagak Lowlands occupy 61,000 km^2 of the Bristol Bay-Kodiak ecoregion. The subregion extends southward from the forested interior lowlands/uplands in the north, covering the northern half of the entire length of the Alaska Peninsula. The western boundary is the Ahklun Mountains, and the eastern boundary is the crest of the Alaska Peninsula Mountains. The lowlands are characterized by rolling terrain with relatively well-drained soils (compared with the Subarctic Coastal Plain) and many lakes. The Nushagak and Kvichak Rivers are the largest flowing water bodies, but numerous other short creeks and rivers are present. This area is characterized by dwarf scrub-shrub and wetland communities. Discontinuous permafrost underlies the northern portion of the subregion.

Elevation ranges from sea level to 150 m for the majority of lowlands. Principal soils are Typic Haplocryands, Typic Vitricryands, Fluvaquentic Cryofibrists, Histic Pergelic Cryaquepts, Pergelic Cryaquepts, and Typic Cryochrepts. Most of these soils are formed in volcanic ash deposits, gravelly glacial till, outwash, or silty alluvium. Sand dunes are found along the coast and some river banks (Gallant et al., 1995).

The mainland Bristol Bay-Nushagak Lowlands have a climate that is transitional between maritime and continental. Along the Alaska Peninsula the climate is maritime. Average annual precipitation of the subregion varies from 30 to 90 cm, with 75 to 250 cm of snow. Average daily temperatures range from –15°C in winter to 18°C in summer. Summer and winter temperatures are highest in the northern part of the subregion. Long, warm summer days promote high primary production in both terrestrial and aquatic communities.

Vegetation of the lowlands is predominantly a dwarf scrub-shrub community. The dominant species are crowberry and lichens. Other species include Labrador tea, azalea, dwarf willows and birch, and mosses. These species prefer the well-drained soils of the subregion. The wetland/bog community includes dwarf arctic birch, berries, sedges, rushes, horsetail, and mosses. Other wetland areas include wet grassy meadows consisting mainly of sedges and rushes, and sedge/moss/bog meadows dominated by mosses, low sedges, cottongrass, and rushes. The few broadleaf forests of the subregion include birch and poplar as the canopy layer, a tall willow/alder shrub understory, and a low understory of prickly rose, berries, birch, and fireweed. White spruce may co-dominate with birch in the canopy.

No information was found specifically related to invertebrates of the Bristol Bay-Kodiak region. Invertebrates are expected to be numerous because water and warm summers are abundant. Mosquitoes are likely to be abundant, and it is assumed that species surviving in the Arctic ecoregion also would be present. These include representatives of the taxa diptera, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, and others. The major taxa in a central Alaskan stream included stoneflies, mayflies, and dipterans (Brown, 1987; and Clay, 1973).

The lowlands provide some waterfowl resting, staging, and breeding habitat, but are not as important to waterfowl (with regard to the number using the subregion) as the Yukon Flats and Subarctic Coastal Plain subregions. The principal species include scaup, pintail, scoters, wigeon, mallards, shovelers, green-winged teal, and canvasbacks. Swans, geese, loons, grebes, and sandhill cranes also are common. Birds of prey such as sharp-shinned hawk, red-tailed hawk, kestrel, raven, great-horned owl, and short-eared owl are all common to the area, and the endangered peregrine falcon is an inhabitant of the subregion. The spruce grouse, ruffed grouse, and ptarmigan may be found in drier areas. Passerines and other small birds are also common, inhabiting the forested and non-forested areas. Gray jay, chickadees, robins, thrushes, warblers, redpoll, pipits, and sparrows are common. Nesting and rearing are likely to occur from May through July. Migratory birds depart for warmer climates by late September or early October.

Mammals inhabiting the bottomlands include brown and black bears, caribou, wolves, weasels, marten, hares, squirrels, voles, and shrews. Moose are frequently abundant in the subregion because of the large amount of water. Caribou are common locally, ranging from the lowlands in winter to the surrounding highlands for the warmer summer months. Many of the mammals are residents, but may hibernate or migrate locally to optimum winter foraging grounds. Aquatic mammals such as mink, muskrat, and beaver are common in the myriad of water bodies of the subregion.

Anadromous and resident fishes are plentiful. Anadromous species include chinook, coho, sockeye, pink, and chum salmon that migrate to upstream spawning beds. Resident species may include northern pike, grayling, whitefish, sucker, sheefish, burbot, sculpin, and stickleback. Becharof Lake on the northeast corner of the subregion is the second largest lake in Alaska and provides a nursery for the world's second-largest run of salmon. Other lakes in this area provide ideal habitat for large populations of salmon, grayling, and rainbow trout. Wood frogs inhabit the Bristol Bay-Nushagak Lowlands. No reptiles are found in this subregion.

31**BROOKS RANGE**

The Brooks Range subregion is delineated by the U.S.-Canada border to the east, the crest of the Brooks Range to the south, the Delong Mountains to the west, and the Arctic Foothills to the north. The mountains range in elevation from 500 m along valley floors to 2,400 m at the mountain crests. The terrain is very rugged with deep valleys, steep mountainsides, and scarce vegetation. Glaciers covered the mountains in the Pleistocene and are still present above 1,800 m.

The Brooks Range was uplifted during the Cretaceous period and is comprised of folded and faulted Paleozoic and Mesozoic bedrock, primarily sandstones, limestone, and metamorphic rock. Permafrost underlies the entire region. Soils of the subregion include Pergelic Cryaquepts, Pergelic Cryumbrepts, and Lithic Cryorthents (Gallant et al., 1995). Valley soils are derived from glacial till and alluvium; very little soil accumulates on the slopes of the mountains. Although soils are often gravelly, silty colluvium and fine-grained alluvium may be present on the valley floors.

The climate of the Brooks Range is mainly influenced by the Arctic. Average daily temperatures range from –30°C to 16°C. Temperatures generally decrease with elevation, but can vary depending on the terrain and in response to the persistent winds. Mean annual precipitation is approximately 28 cm, including 16 cm of snowfall (Gallant et al., 1995).

The northernmost portion of the Brooks Range subregion is a zone of transition between the moist upland vegetation to the north and the mountainous, well-drained dwarf scrub communities to the south. Because of erosion, shallow soils, high winds, and harsh climate, vegetation is scarce in the mountainous areas. The dominant mountainous plant species include low-lying shrubs such as dwarf alder, mountain avens, and dwarf willow. Herbaceous plants include lichens and some Carex species. In the few graminoid communities, sedges, willow, and mosses may be abundant (Gallant et al., 1995).

Invertebrate species are few in the mountainous climate of the Brooks Range because of the extreme weather conditions and physiography. Within the low-lying and moist habitats, the species present are similar to those found in the uplands of the Arctic Foothills and include diptera, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Aquatic invertebrates of the few lakes may include copepods, rotifers, or cladocerans. The primary benthic invertebrates are chironomids; however, dipterans, oligochaetes, steroptera, coleoptera, and gastropoda may also occur (U.S. Navy, 1977; Holmquist, 1975; and Hobbie, 1973).

Most birds found in the Brooks Range are limited to lower elevations. The diversity of passerine species found at the lower elevations of the Brooks Range subregion are similar to those in the adjoining Arctic Foothills. With increasing distance southward and a corresponding increase in altitude, the diversity and abundance of birds decrease dramatically. Wheatear, water pipit, ptarmigan, and raven inhabit the highest altitudes. Rough-legged hawks and ravens may be found nesting on cliffs overlooking foraging areas.

The lack of ground cover over much of the Brooks Range limits the numbers of large and small herbivorous mammals. This, in turn, limits the presence of larger, predatory mammals. At lower elevations, shrews, voles, and lemmings may be present. At higher elevations, small to medium-size mammals may be limited to the Alaska vole, marmot, and arctic hare, all of which may inhabit rocky substrates. Caribou migrate through passes of the Brooks Range, but do not spend large amounts of time foraging or resting in the subregion. Dall sheep are relatively common in the Brooks Range. Larger mammalian carnivores such as wolves may be found in the mountains, but usually only in the vicinity of Dall sheep or migrating caribou.

There are few fish in the mountainous regions of the Arctic. Some lake trout have been planted in mountain lakes.

32COASTAL WESTERN HEMLOCK-SITKA SPRUCE FORESTS

The subregion contains a consistent habitat dominated by western hemlock and Sitka spruce forests. The understory, shrub, and ground cover layers are dependent upon the cool, wet climate and the shade provided by the needleleaf canopy.

The terrain consists of relatively low elevation (<500 m except a few 1,000 m peaks), steep slopes, alluvial fans, floodplains, outwash plains, scattered moraines, river terraces, and river deltas. Geologic formations are Upper Cretaceous sandstone and slate. Dominant soils are Terric Cryohemists, Andic Cryaquods, Andic Humicryods, Lithic Humicryods, and Typic Humicryods. These include silty, clayey, and peaty soils (Gallant et al., 1995).

The climate of this portion of the subregion is maritime with cool summers and mild winters. The average daily minimum and maximum temperatures reach –3°C in winter and 18°C in summer, respectively. There are up to seven months of frost-free weather per year. Annual rainfall averages 135 cm, with up to 80 cm of snow.

The abundant rainfall, rich soils, and long growing season produce dense forest, scrub, and wetland communities. The forests are dominated by western hemlock or Sitka spruce. However, silver fir, subalpine fir, lodgepole pine, Pacific yew, alder, or black cottonwood may be dominant or co-dominant within particular areas. The understory varies slightly depending on the canopy layer, but includes alder, willow, currant, salmonberry, prickly rose, bearberry, cranberry/huckleberry, dogwood, devil's club, and brambles. A lush floor covering of bluebell, false lily-of-the-valley, laceflower, deer cabbage, twisted stalk, goldthread, reed-grass, and sedges also may be present. The tall and dwarf scrub-shrub communities may have species such as willow, alder, grasses, horsetail, fireweed, monkshood, bluebell, and mosses. Higher elevation scrub-shrub species may include mountain heath, cassiope, meadow spirea, blueberry, lupine, valerian, mosses, and lichens. Bogs and wetlands may be inhabited by crowberry, rosemary, kalmia, willow, bluejoint, horsetail, sedges, mosses, marigold, buckbean, and marsh fivefinger.

Invertebrates of the coastal forests are similar to those found in other regions of Alaska. Mosquitoes, blackflies, and gnats are abundant. Other taxa include diptera, trichoptera, coleoptera, hemiptera, and arachnids. Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, and others. Major taxa in a central Alaskan stream included stoneflies, mayflies, and dipterans (Brown, 1987; and Clay, 1973). These species are likely to inhabit the streams of the western hemlock/Sitka spruce forest.

The diversity of bird species reflects the abundant vegetation and well-developed layers (e.g., canopy, understory, and ground cover) found in the forests of the subregion. Birds found in the western hemlock-Sitka spruce forests include many passerines and other small bird species, as well as upland species such as grouse and ptarmigan. Many of the passerine species are migratory, using the forest as resting and staging grounds during migration, but many species also nest in the subregion. These species include sparrows, warblers, kinglets, chickadees, wrens, siskins, pipits, longspurs, and murrelets. Scavengers, such as ravens, crows, and magpies, are common. Birds of prey, such as bald eagles and great horned owls, are also common. Nesting and rearing occur in June and July, respectively, and the migratory birds depart for warmer climates by mid- to late September. Migratory waterfowl and shorebirds are not common inhabitants of the forested areas, but may be found in localized areas where surface water and meadow habitat are present. The threatened peregrine falcon may be found in this subregion. Shorebirds pass over these coastal forests, preferring the barren rocky cliffs of the more western coastline of Alaska.

Mammals inhabiting the forested areas include brown bear, red fox, weasel, tundra vole, and the little brown bat. These species are residents, but may hibernate through the winter. River otters are the most common aquatic mammal, but mink, beavers, and muskrats also are present.

Freshwater fishes such as salmon (chinook, coho, sockeye, pink, and chum), Dolly Varden, rainbow trout, and steelhead, may be found in rivers and/or lakes of the lowlands. Most of these species are anadromous. Some lakes and ponds are deep enough to support year-round fish populations such as rainbow trout.

The wood frog, spotted frog, and western toad may inhabit all or portions of this subregion. No reptiles inhabit the subregion.

33COOK INLET

The Cook Inlet subregion includes approximately 28,000 km^2 of level to rolling lands along the eastern and northwestern shores of Cook Inlet. There are a variety of habitats, mostly forested with marshy riparian borders along meandering streams, and many lakes, swamps, and bogs. There is very little permafrost underlying the subregion.

Elevations range from sea level to 600 m with slope gradients less than 3 degrees. Bedrock consists of poorly consolidated, Tertiary, coal-bearing, sedimentary rock. Marine and lake deposits and aeolian deposits mantle most of the subregion. Principal soils are Haplocryands, Sphagnic Borofibrists, Terric Borosaprists, Typic Borohemists, Andic Haplocryods, and Andic Humicryods. Most of these soils are formed in gravelly clay loam, gravelly sandy loam, and gravelly sands (Gallant et al., 1995).

The Cook Inlet subregion has the mildest climate of mainland Alaska and includes characteristics of both maritime and continental climates. Average annual precipitation varies from 38 to 68 cm, including annual snowfall of 160 to 255 cm. Average daily temperatures range from –15°C to 18°C in winter and summer, respectively. The subregion is usually frost-free from May through September. The long, relatively warm summer days promote high primary production in both terrestrial and aquatic communities.

A wide variety of vegetation communities exist within the Cook Inlet area, but needleleaf, broadleaf, and mixed forests are the most widespread. The tree species associated with these communities include white spruce on drier soils, black spruce and cottonwood on wetter soils, quaking aspen and balsam poplar on dry slopes, and paper birch in well-drained areas. Within these forests a low shrub layer is comprised of birch, alder, willow, berries, Labrador tea, prickly rose, and crowberry. A herbaceous layer is present, consisting of horsetail, twinflower, blue-joint, or mosses depending on soil moisture content. Tall scrub thickets include alder, willows, and mosses. Some dry to moist areas support low-lying grassy communities of fescue, mid-grasses, bluejoint, monkshood, and bluebell. Wetter swamps, bogs, and grassy areas support alder, high bush cranberry, currant, prickly rose, sedges, dogwood, horsetail, birch, willow, bog rosemary, leatherleaf, buckbean, marsh fivefinger, marsh marigold, and mosses.

The mild, relatively wet climate and abundance of water supports mosquitoes, blackflies, gnats, sawflies, and leafhoppers. Other taxa include dipterans, trichoptera, coleoptera, hemiptera, and arachnids. Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, and others. Major taxa in a central Alaskan stream included stoneflies, mayflies, and dipterans (Brown, 1987; and Clay, 1973). These species are likely to inhabit the streams of Cook Inlet.

The Cook Inlet subregion provides waterfowl resting, staging, and breeding habitat. The principal species include mallard, pintail, green-winged teal, wigeon, goldeneye, scaup, and harlequins. Swans, geese, loons, grebes, and sandhill cranes also are present. Spruce grouse and ptarmigan may be found in drier upland areas. Birds of prey such as eagles, sharp-shinned hawk, red-tailed hawk, kestrel, raven, great-horned owl, and short-eared owl are all common to the subregion, and the endangered peregrine falcon inhabits the area. Passerines and other small birds are also common in the subregion and include longspur, gray jay, chickadees, robins, thrushes, warblers, redpoll, pipits, sparrows, and woodpeckers, among others. Nesting and rearing are likely to occur in June and July, respectively. Migratory birds may use the Cook Inlet area only for staging grounds for their northward migration in the spring and southward journey in the fall. Migratory birds arrive in April or May, and depart for warmer climates by late September and early October.

Mammals inhabiting the Cook Inlet area include brown and black bears, moose, caribou, wolves, lynx, coyote, weasels, mink, marten, hares, squirrels, voles, and shrews. Moose are abundant in the subregion. Caribou may be common in localized areas. Aquatic mammals such as mink, muskrat, and beaver are common in the myriad of water bodies in the subregion.

Anadromous and resident fishes are common. Anadromous species include chinook, coho, sockeye, pink, and chum salmon, and steelhead. Resident species include rainbow trout, lake trout, kokanee, char, grayling, whitefish, sucker, sheefish, burbot, and stickleback.

The wood frog, spotted frog, and western toad all inhabit the subregion. No reptiles inhabit the Cook Inlet subregion.

34COPPER PLATEAU

The 17,000 km^2 Copper Plateau subregion lies in a Pleistocene lake bed. It includes flat to gently rolling lands bordered to the north and west by the Alaska Range, to the south by Pacific Coastal Mountains, and to the east by the Wrangell Mountains. Numerous small thaw lakes dot the landscape, narrowly bordered by bog communities and surrounded by needleleaf forests. The subregion has a nearly continuous, shallow permafrost layer.

Elevations range from 420 to 900 m with slope gradients less that 2 degrees. Pleistocene lake deposits that are up to hundreds of meters thick underlie the subregion. The Copper River is the main drainage for the region. It is a glacially fed stream that meanders through the Copper Plateau before it passes through the Pacific Coastal Mountains to the Gulf of Alaska. Principal soils are Histic Pergelic Cryaquepts, Aquic Cryochrepts, Typic Cryochrepts, Pergelic Cryaquolls, and Typic Cryoborolls. Most of these soils are developed on silty loess, although some are developed in gravelly glacial drift (Gallant et al., 1995). Well-drained soils occur in the uplands, but most soils in the subregion are poorly drained.

The Copper Plateau climate is typically continental with average daily winter and summer temperatures of –27°C to 21°C, respectively. Average annual precipitation varies from 25 to 46 cm (north to south) including annual snowfall of 100 to 190 cm. The subregion may experience frosty weather throughout the year, but the growing season may be as long as 11 weeks in June, July, and August.

Vegetation of the Copper Plateau is nearly monotypic and reflects the abundance of surface water caused by poor drainage and a shallow permafrost table. Needleleaf forests of black and/or white spruce are the most widespread communities. The understory of these forests may include willow, resin birch, various berries, prickly rose, sedges, and mosses. Some stands of quaking aspen are found on the higher, better-drained hillsides. Low scrub bogs surround the wetlands and meandering streams and include species such as birch, berries, Labrador tea, sedges, and mosses. There are also a few grassy, wet-meadow communities comprised mainly of sedges, buckbean, coltsfoot, and mosses.

The relatively mild climate and abundance of surface water supports many invertebrates, including mosquitoes, blackflies, gnats, sawflies, and leafhoppers. Other taxa present in the subregion include trichoptera, coleoptera, hemiptera, arachnids, and dipterans. Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, and others. Major taxa in central Alaskan streams include stoneflies, mayflies, and dipterans (Brown, 1987; and Clay, 1973); these species are likely to inhabit the streams of the Copper Plateau.

The Copper Plateau subregion provides a large area of important waterfowl resting, staging, and breeding habitat. The principal species include mallard, pintail, green-winged teal, wigeon, goldeneye, scaup, and harlequins. Swans, geese, loons, grebes, and sandhill cranes also may be present. Spruce grouse and ptarmigan may be found in upland areas. Birds of prey such as eagles, sharp-shinned hawk, red-tailed hawk, kestrel, raven, great-horned owl, and short-eared owl are common in the subregion, and the endangered peregrine falcon inhabits the area. Passerines and other small birds are abundant, including longspur, gray jay, chickadees, robins, thrushes, warblers, redpoll, pipits, and sparrows, among others. Nesting and rearing are likely to occur in June and July, respectively. Some migratory birds use the Copper Plateau only for staging grounds along their northward migration in the spring and southward journey in the fall. Nesting migratory birds arrive in April or May, and depart for warmer climates by late September and early October.

Mammals inhabiting the Copper Plateau subregion include brown and black bears, moose, caribou, wolves, lynx, coyote, weasels, mink, marten, hares, squirrels, voles, and shrews. Moose are abundant in the subregion. Caribou may be common in localized areas. Aquatic mammals such as mink, muskrat, and beaver are common in the myriad of water bodies of the subregion.

Anadromous fishes are common in rivers and streams. Anadromous species include chinook, coho, sockeye, pink, and chum salmon, and steelhead. Some of the larger lakes and ponds support resident species such as rainbow trout, lake trout, kokanee, char, grayling, whitefish, sucker, sheefish, burbot, and stickleback.

The wood frog and western toad inhabit the Copper Plateau subregion. No reptiles inhabit the Copper Plateau.

35INTERIOR BOTTOMLANDS

The Interior Bottomlands include approximately 100,000 km^2 of flat or nearly flat lands along the central and/or lower portions of the Yukon, Koyukuk, Tanana, and Kuskokwim Rivers. The bottomlands are marshy basins dotted with meandering streams, and many thaw and oxbow lakes. This area is characterized by forested lowlands and wetlands. This subregion is similar (except for weather) to the Yukon Flats subregion found in the central eastern portion of the Interior ecoregion. Permafrost is widespread across the bottomlands.

Elevations range from 120 m in the majority of the subregion to 600 m on the few hills that are present, particularly in the eastern part of the bottomlands. Fluvial and aeolian deposits underlie most of the subregion, with gravel and morainal deposits in some areas. Principal soils are Histic Pergelic Cryaquepts, Pergalic Cryoquepts, Aquic Cryochrepts, Typic Cryochrepts, and Typic

Cryofluvents. Most of these soils are formed in loess and alluvial materials (Gallant et al., 1995).

The Interior Bottomlands have a continental climate. Precipitation varies from 28 cm in the eastern portions of the region, up to 40 cm in the west. Annual snowfall ranges from 95 to 205 cm. Average daily temperatures range from –33°C to 22°C in winter and summer, respectively. Summer temperatures are highest in the eastern part of the subregion. The long, warm summer days promote high primary production in both terrestrial and aquatic communities.

Vegetation within the Interior Bottomlands consists mainly of closed stands of needleleaf, broadleaf, and mixed forests with intermixed tall scrub-shrub communities and smaller areas of bogs, marshes, and wet grassy meadows. Needleleaf forests include white spruce in drier areas and black spruce in poorly drained areas. Broadleaf species include quaking aspen and balsam poplar. The tall scrub-shrub community occurs both as an understory to the dominant forests, and as separate vegetation stands where needleleaf and broadleaf species are absent. Constituents of the scrub-shrub include resin birch, alder, and willow with prickly rose, Labrador tea, and berries. The forest herb layer frequently includes bluejoint, bluebell, horsetail, and mosses. The bogs, marshes, and wet meadow species principally include Labrador tea, dwarf Arctic birch, berries, sedges, rushes, horsetail, and mosses.

Invertebrates are expected to be numerous in the Interior Bottomlands because of the large amounts of surface water and relatively warm summers. Mosquitoes are abundant, and other species of diptera, trichoptera, coleoptera, hemiptera, and arachnids are also likely to be present (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, copepods, rotifers, and cladocerans. Major taxa in a central Alaskan stream included stoneflies, mayflies, and other dipterans (Brown, 1987; and Clay, 1973). Chironomids are likely to be the most numerous benthic invertebrates; however, steroptera, coleoptera and gastropoda may also occur (U.S. Navy, 1977; Holmquist, 1975; and Hobbie, 1973).

The Interior Bottomlands provide waterfowl resting, staging, and breeding habitat. The principal species include scaup, pintail, scoters, wigeon, mallards, shovelers, green-winged teal, and canvasbacks. Swans, geese, loons, grebes, and sandhill cranes also are common. Birds of prey such as rough-legged hawk, sharp-shinned hawk, red-tailed hawk, kestrel, raven, great-horned owl, and short-eared owl are all common to the area, and the endangered peregrine falcon also inhabits the area. The spruce grouse, ruffed grouse, and ptarmigan may be found in drier areas. Passerines and other small birds are also common in the subregion and include gray jay, chickadees, robins, thrushes, warblers, redpoll, pipits, and sparrows, among many others. Nesting and rearing are likely to occur in June and July, respectively. Migratory birds depart for warmer climates by late September and early October.

Mammals inhabiting the bottomlands include brown and black bears, caribou, wolves, weasels, marten, hares, squirrels, voles, and shrews. Moose are abundant in the subregion. Caribou may be common in localized areas. Many of these species are resident, but may hibernate or migrate locally to optimum foraging grounds. Semi-aquatic mammals such as muskrat, mink, and beaver are common in the myriad of water bodies in the subregion.

Anadromous and resident fishes are common. Anadromous species include chinook, coho, and chum salmon that may spawn in the bottomlands or migrate farther upstream. Resident species are northern pike, grayling, whitefish, sucker, inconnu, burbot, and stickleback.

Wood frogs also inhabit the Interior subregion. No reptiles are found in the subregion.

36INTERIOR FORESTED LOWLANDS AND UPLANDS

This subregion extends from Norton Sound through the Northwest ecoregion, across the interior of Alaska to the U.S.-Canada border. Within the Northwest ecoregion, the forested lowlands/ uplands are limited to the lower elevations of the Kobuk and Tagagawik River watersheds, and inland from Norton Sound. The subregion contains a highly variable set of habitats dominated by spruce and hardwood forests. Fires are common in this subregion.

The terrain consists of rolling lowlands, plateaus, and rounded hills up to 700 m in elevation. The subregion is underlain by Mesozoic and Paleozoic sedimentary and volcanic rock mantled by alluvium and colluvial deposits. Dominant soils are Histic Pergelic Cryaquepts, Pergelic Cryaquepts, Aquic Cryochrepts, Pergelic Cryochrepts, Typic Cryochrepts, Typic Cryorthents, and Pergelic Cryumbrepts. These soils are derived from shallow, silty alluvium and loess in lowlands, and silty loess and colluvial materials in uplands (Gallant et al., 1995).

The climate of this subregion is continental except in the western portions near the Chukchi and Bering Sea coasts where an Arctic maritime climate is predominant. Summers are short and warm while winters are very cold. The lowlands are generally frost free from June into September. Temperatures are affected negatively with increasing elevation and distance from the ocean. Yearly rainfall averages 25 cm with 125 cm falling as snowfall. Snow covers the ground for nearly six months, with significant depths remaining longer at higher elevations and on north-facing slopes.

Open forests of white and black spruce, paper birch, and balsam poplar occur across much of the lowland areas. Tall willows are found along streams throughout the area. Fire from lightning strikes creates disturbed uplands that may be re-colonized by bluejoint grass before successional change leads to fireweed, shrubs, and eventually back to forests. The tall and low scrub-shrub communities are dominated by willow, birch, or alder species. Shrub species such as Labrador tea, blueberry, cranberry, crowberry, and rosemary may be found in bog areas, and wet meadow/tundra communities are dominated by sedges. Aquatic freshwater plants found in the region include yellow marsh-marigold, swamp horsetail, marestail, duckweed, buckbean, pond lilies, pondweed, marsh cinquefoil, and bur reed.

Little information was found regarding the invertebrates of the region. It is assumed that species surviving in the Arctic ecoregion would be present. These species include diptera, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Aquatic invertebrates might include copepods, rotifers, or cladocerans. It is likely that mayflies, stoneflies, and caddis flies are also present. The primary benthic invertebrates are likely to be chironomids. However, dipterans, oligochaetes, steroptera, coleoptera and gastropoda may also occur (U.S. Navy, 1977; Holmquist; and 1975, Hobbie, 1973).

Birds found in the Interior Forested Lowlands and Uplands include herbivores, omnivores, and carnivores. Upland species such as ptarmigan and passerines are the most numerous species. Many of the passerine species are migratory and use the subregion for nesting, or as resting and staging grounds during their migration. These species include gray jay, robins, warblers, redpolls, tree swallows, and sparrows. Nesting and rearing occur in June and July, and the migratory birds depart for warmer climates by mid- to late September. Birds of prey such as rough-legged hawks, short-eared owls, and ravens also are common. The threatened Peale's peregrine falcon may be found in this subregion.

Mammals inhabiting the forested areas include brown and black bears, moose, caribou, wolves, weasels, voles, shrews, and the little brown bat. Most of these species are residents but may hibernate or migrate locally to optimum winter foraging grounds. The small mammals are very important to the ecosystem as prey items. River otters, muskrat, beaver, and mink may be found along some of the rivers, streams, and lakes of the subregion.

Freshwater fishes such as inconnu (sheefish), cisco, whitefish, salmon (coho, pink and chum), grayling, char, pike, smelt, eulachon, blackfish, stickleback, and sculpin may be found in rivers and/or lakes of the subregion. Most of these species are anadromous to some extent and have some tolerance to salt or brackish waters. Their migration is usually dependent on the freeze-thaw cycles of the rivers and bays of the subregion. Many of the lakes and ponds in the coastal plain are deep enough that they do not freeze to the bottom and thus support year-around fish populations. Smaller lakes frequently have poor water quality with low nitrogen and oxygen content, freeze solid in winter, and so do not support fish populations.

Wood frogs are the only amphibian that may inhabit the subregion. No reptiles are found in the subregion.

37INTERIOR HIGHLANDS

The Interior Highlands subregion is usually surrounded by Interior Forested Lowlands and Uplands, and are composed of steep, rounded mountains with rugged peaks, rising to 1,800 m elevation. The mountains are underlain by Paleozoic and Precambrian metamorphic rock, felsic volcanic rock, and intrusive rock. Steep slopes have very little soil cover, whereas the valley floors are covered by alluvium and colluvium (Gallant et al., 1995). Dominant soils are Histic Pergelic Cryaquepts, Typic Cryochrepts, Pergelic Cryumbrepts, Lithic Cryorthents, and Typic Cryorthods. Most of these soils are formed in gravel, which has weathered from local rock. Permafrost and freeze-related features are evident, but permafrost may be discontinuous in the central and southern portions of the subregion.

The climate is considered continental. Summer temperatures are expected to drop with altitude while precipitation is expected to increase. Winters are cold and summers are short and warm. Snow remains on mountain peaks and shaded hillsides longer than in the valleys and surrounding lowlands.

The vegetation of the Interior Highlands is classified as alpine tundra. This includes a range of habitats, including moist grassland, open needleleaf forests, dwarf scrub, and barren areas at higher elevations. The lower elevations of the subregion are dominated by forest with dense ground cover, while the higher elevations are limited to low-growing species only. The wind and colder temperatures at higher elevations are a key factor in limiting the growth of taller and more dense vegetation. The open canopy needleleaf forests are dominated by white spruce or a combination of white and black spruce. Birch and aspen trees may also be present. The shrub layer in these forests frequently include resin birch, alder, willow, prickly rose, and buffaloberry.

Mosses and lichens provide nearly complete ground cover. Grassy meadow communities (sedge tussocks and mosses) are dominant in poorly drained areas. At higher elevations, mountain avens dwarf scrub communities dominate, with prostrate willow, cranberry, bearberry, mosses, and lichens. Some areas at higher altitudes may be dominated by dwarf willow scrub or berries. The berries produced by many of the interior highland plants provide a large amount of food for herbivorous and omnivorous birds and mammals.

Mosquitoes and other types of terrestrial invertebrates such as diptera, trichoptera, coleoptera, hemiptera, and arachnids will be abundant in the highlands. Freshwater aquatic/benthic invertebrates are limited since there is little surface water within this subregion. However, stoneflies, mayflies, and dipterans could be found in any lower elevation streams (Brown, 1987; and Clay, 1973).

Birds found in the Interior Highlands include many upland species such as grouse, ptarmigan, and passerines; however, decreasing numbers of birds are found with increasing altitude. Most passerine species are migratory and use the subregion as nesting or resting and staging grounds during their migration. These species include gray jay, chickadees, robins, thrushes, warblers, redpoll, pipits, and sparrows. Lapland longspur, snow bunting, redpolls, grouse, and ptarmigan are all resident species. Nesting and rearing are likely to occur in June and July, respectively, and the migratory birds depart for warmer climates by mid- to late September. Birds of prey such as rough-legged hawk, short-eared owls, and ravens also are common. The threatened peregrine falcon may be found in this subregion.

Mammals inhabiting the forested areas include brown and black bears, moose, caribou, wolves, weasels, marten, hares, pika, marmot, squirrels, voles, and shrews. Some of these species such as the pika and hare are suited to the rocky nature of the higher elevations, while others such as the wolves, weasels, and bears may prefer the lower elevation, open forests. Most of these species are resident year-round, but may hibernate or migrate locally to optimum foraging grounds. The small mammals are critical to the ecosystem as prey items. Aquatic mammals are uncommon because lakes and large streams are minimal.

Freshwater fishes are uncommon because of the few lakes, ponds, and streams in the subregion. Some species such as grayling, stickleback, and sculpin may be present in small numbers in streams and large lakes.

38PACIFIC OCEAN

The Pacific Ocean subregion extends from Dixon Entrance in Southeast Alaska west to Unimak Pass at the end of the Alaska Peninsula, and south to the boundary of the U.S. Exclusive Economic Zone. Dominant physical characteristics in the region include a broad continental shelf; the Alaska Current/Alaska Stream, which is the eastern and poleward boundary of the large-scale, counter-clockwise rotating subarctic current; and a narrow coastal current driven by freshwater runoff. Water flow generally parallels the continental shelf. The Gulf of Alaska/Pacific Ocean is one of the most active meteorological regions on earth as a result of the frequent passage of storms along the Aleutian storm track.

The climate is typically mild and wet, with temperatures remaining above freezing for much of the year. Winter temperatures are not cold enough to form a continuous ice cover.

Continental shelf waters in this subregion are extremely productive, supporting a rich diversity and high biomass of plankton, shellfish, fish, seabirds, and marine mammals. Phytoplankton are abundant and provide critical forage for whales and other species. Marine algae species play an important role in the food chain of bird and fish species inhabiting islands and nearshore areas. The algae are present at various depths and associated with their preferred bottom substrate (i.e., rock, sand, or silt). Over 100 species of algae exist within at least three taxonomic groups, including Chlorophycophyta, Phaeophycophyta, and Rhodophycophyta (Lebednik and Palmisano, 1977).

Shellfish of the subregion include abalone, king crab, tanner crabs, razor clams, and shrimp. Barnacles, snails, limpets, and starfish also are common. Other species may include representatives of the taxa Porifera (sponges); Cnidaria (hydrozoans); Ctenophora (comb jellies); Platyhelminthes (flatworms); Nemertea (ribbon worms); Mollusca (gastropods, bivalves, and cephalopods); Annelida (segmented worms); Sipuncula (peanut worms); Arthropoda (barnacles, shrimp, and crabs); Bryozoa (moss animals); Brachiopoda (lamp shells); Phoronida (phoronids); Echinodermata (echinoids, crinoids, etc.); and Chordata (thaliaceans and allies) (Barr and Barr, 1983). The nearshore/estuarine environments are described in Coastline/Estuary subregional descriptions for the Aleutian Islands, Southcentral, Southeast, Southwest, and Bristol Bay/Kodiak Island subregions.

The highly productive waters in the Pacific Ocean are home to a diverse assemblage of more than nine million seabirds. Most of the seabirds of the Gulf of Alaska are associated with coastline cliffs and shorelines of the Aleutian Islands, mainland, and numerous Alexander

Archipelago islands. These shore-dependent birds use the open water to varying degrees, some staying close to shore and others spending a great deal of time out to sea. These species include fulmar, shearwaters, storm-petrels, cormorants, gulls, terns, kittiwakes, murres, guillemots, murrelets, auklets, and puffins. Millions of shearwaters that breed in the southern hemisphere "winter" in this region during the northern summer. Three species of albatross (including the endangered short-tailed albatross) may inhabit the skies above the Gulf of Alaska and rarely touch down on land.

At least 26 species of marine mammals, including sea otters, seals, sea lions, and small and large cetaceans, inhabit the waters of the Gulf of Alaska/Pacific Ocean. The whales found in the Pacific Ocean subregion include beluga, gray, bowhead, blue, humpback, sei, finback, sperm, little piked, beaked, right, pilot, and orca. Other marine mammals include porpoises.

Fish of the Pacific Ocean include all major salmon species, cod (arctic and saffron), capelin, arctic char, Dolly Varden, steelhead, lingcod, halibut, rockfish, herring, eulachon, and many others. Many of these species are migratory, some returning to rivers to spawn, and others retreating to deeper, warmer, or flowing waters during the winter. Other common species include perch, sablefish, pollock, sole, flounder, lampreys, sharks, skates, smelts, lightfishes, viperfishes, lances, grenadier, sandfishes, ronquils, pricklebacks, poachers, and others (Simenstad et al., 1977).

39NORTHWEST COASTLINE/ESTUARY

The Northwest Coastline/Estuary subregion habitat occupies a narrow band along the coast and is irreplaceable to many species of fish and wildlife, especially cliff nesting birds. The habitat is variable, including estuaries, lowland deltas, and barren, rugged cliffs rising from the water to heights of 700 m. This subregion provides important biological function, including resting, nesting, feeding, rearing, and migration staging grounds for many of the fish, marine mammals, waterfowl, seabirds, and shorebirds of the Arctic. Of particular biological importance within this subregion are the seaside cliffs and bays, inlets, lagoons, and estuaries such as the Selawik Lake/Hotham Inlet complex.

Most of the subregion lies between sea level and an elevation of 500 m. Mesozoic and Paleozoic sedimentary and volcanic rock are the principal geologic formations. Soils are usually thin and include Histic Pergelic Cryaquepts, Pergelic Cryaquepts, Aquic Cryochrepts, Pergelic Cryoquepts, Typic Cryochrepts, Typic Cryorthents, and Pergelic Cryumbrepts (Gallant et al., 1995).

Lowland soils and estuarine sediments include silty alluvium and loess. Beach ridges frequently include sand and gravelly sand.

The coastal climate is maritime, dominated by the effects of the Chukchi Sea in Kotzebue Sound and the Bering Sea in Norton Sound. Winds are persistent and strong, frequently from the northwest or southwest. Long, severe winters are characteristic of the subregion, with ice covering the coastal waters seven to eight months of the year. Temperatures vary between northern to southern portions of the subregion, but daily averages range from –18°C in winter to 13°C in summer. Generally, there are two to three months of frost-free weather each year. Precipitation occurs mainly in late summer and early fall and averages 25 cm with up to 125 cm of snow.

The type and abundance of vegetation in the coastline community is mainly a function of the steepness of the banks/cliffs; the amount of exposure to prevailing winds, ice, and wave action; the type of soil/sediment; and salinity. Beaches may be dominated by grasses such as beach rye and other species such as honckenya, beach plea, and groundsel. Cliffs are generally sparsely vegetated with bryophytes, lichens, and some grass clumps where there is soil. Brackish species include ditch grass, horned pondweed, alkali grasses, honckenya, fivefinger, arrow grass, and reed grasses. Marine aquatic plants important to bird species include eel grass and ditch grass. Phytoplankton (nannoplankton) and algae may also be found in the marine and estuarine areas. The plants within the coastline community play a critical role in support of migratory shorebirds and waterfowl that migrate through or nest in this subregion each spring.

Invertebrates found within the estuaries include pelecypods, priapulids, polychaetes, tunicates, isopods, mysids, and amphipods. Zooplankton such as cladocerans and copepods are also present. These few species provide a critical production and decomposition role within the estuarine ecosystem and serve as the food base for many higher trophic-level species.

Birds inhabiting the coastline community are predominantly migratory species that use the cliffs and beach ridges as nesting areas. They begin arriving in mid-April and May. A large proportion of the birds use this coastline as a staging area before moving farther north (in the spring) or south (in the fall) to their preferred nesting or winter areas. Nesting and rearing occur in June and July, respectively, and the birds depart for warmer climes by mid- to late September. Migratory birds found along the coastline primarily include seabirds, shorebirds, waterfowl. The most common seabirds include auklets, storm-petrels, murres, and puffins. Many of these and other seabirds nest only along the Alaska coast and are sensitive to human intrusion during the nesting period. The federally threatened spectacled eider and endangered Eskimo curlew may be found within this subregion. Many species of waterfowl are also present along the coastline, especially the estuaries of the Selawik River. Northern pintail, scaup, and teal are the most numerous waterfowl, but scoters, mallards, wigeon, harlequins, and mergansers may also be found. Shorebirds are also numerous, including sandpipers, plovers, godwits, and curlew.

Mammals use the coastline habitats seasonally, depending on the presence of pack ice and snow cover. Species inhabiting this area include polar bears, caribou, muskox, reindeer, foxes, weasels, mink, ground squirrels, voles, sea otters, seals, and walrus. Polar bears are present on the coastline only in the winter when pack ice reaches the shore. Foxes may be present year-round, but their primary prey items may change from small mammals to young birds depending on the season and preferred prey populations. Where soil conditions allow burrowing, small mammal populations may develop in nearshore areas. However, the sandy/gravelly conditions generally do not support burrows, and the small mammals usually remain farther inland. Caribou, moose, muskoxen, and reindeer are also be found in certain areas within this subregion. The most common uses of the coastline by marine mammals include feeding and haulout.

The estuarine waters, large and small streams, lakes, and ponds provide habitat for anadromous and resident fish. Many of the fishes within the estuaries are subject to seasonal environmental influences such as ice and water temperature. Species frequently found within the nearshore coastal estuaries include salmon, sheefish, whitefish, burbot, pike, lake trout, cisco, char, Dolly Varden, and Arctic grayling. Other species such as flounder, cod, and herring also may be present.

40OGILVIE MOUNTAINS

The Ogilvie Mountains are a small subregion of 11,000 km^2 along the U.S.-Canada border east-northeast of Fairbanks. These are flat-topped hills (900 to 1,300 m in elevation) eroded from an old plateau, and broad valleys that contain numerous tributaries of the Yukon River. The hills are underlain by metamorphic and sedimentary rock, including dolomite, phyllite, argillite, limestone, shale, chert, sandstone, and conglomerate. Much of the region is underlain by permafrost. Related features are present such as pingos, hummocks, and ice wedge polygons.

The soils are Histic Pergelic Cryaquepts, Typic Cryochrepts, and Pergelic Cryorthents. Most of these soils are formed from weathered local rock and from loamy alluvial sediments derived from the uplands. Floodplains may include silty loess (Gallant et al., 1995).

The climate is considered continental, and precipitation is likely to range from 50 to 65 cm per year, with 130 to 205 cm of snow. Temperatures range from an average daily winter minimum of –32°C to an average daily summer maximum of 22°C.

Areas exposed to wind and weather are dominated by moist, grassy meadow species, primarily including tussock-forming sedges. Lower hillslopes and valleys are covered with needleleaf and broadleaf forests or tall scrub-shrub communities. The needleleaf, broadleaf, and mixed forests include white spruce in drier areas and black spruce in poorly drained areas. Broadleaf species include quaking aspen and balsam poplar. The tall scrub-shrub community occurs both as an understory to the dominant forests, and as a separate vegetation stand where needleleaf and broadleaf species are absent. Constituents of the scrub-shrub community include resin birch, alder, and willow with prickly rose, Labrador tea, and berries. The forest herb layer frequently includes bluejoint, bluebell, horsetail, and mosses. The wet meadow species principally are sedges, dwarf Arctic birch, low-lying berries, and mosses.

Little information was found regarding the invertebrates of the Ogilvie Mountains subregion. The relative dryness of the subregion indicates that a less diverse array of invertebrates would be encountered compared with the adjacent Interior Bottomlands or Yukon Flats subregions. However, the types of terrestrial invertebrates present may include diptera, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Riverine aquatic and benthic invertebrates inhabit the many valley streams, and the major taxa include stoneflies, mayflies, and other dipterans, chironomids, steroptera, coleopter, and gastropoda (Brown, 1987; and Clay, 1973).

Relatively few waterfowl inhabit the waterways of the Ogilvie Mountains. Gallinaceous species such as grouse and ptarmigan are common, feeding on the berries and broadleaf tree buds. Passerines and other small birds are also common in the subregion and include chickadees, robins, thrushes, warblers, redpoll, pipits, and sparrows, among others. Birds of prey such as sharp-shinned hawk, red-tailed hawk, kestrel, raven, great-horned owl, and short-eared owl are all common to the area, and the endangered Peale’s peregrine falcon inhabits the area. Nesting and rearing are likely to occur in June and July, respectively. Migratory birds depart for warmer climates by late September and early October.

Mammals inhabiting the forested areas include brown and black bears, wolves, weasels, marten, hares, marmot, squirrels, voles, and shrews. Moose may be found in the subregion but are not abundant because of the limited surface water. Caribou herds may use portions of the Ogilvie

Mountains at certain times of the year during migration. Aquatic mammals such as muskrat, mink, and beaver may be found in some areas of the subregion but are not numerous.

Chinook, coho, and chum salmon are anadromous species found in some of the larger streams of the Ogilvie Mountains. Resident species are limited by the small size of many of the streams and ponds found in the area, but may include northern pike, grayling, whitefish, sucker, sheefish, burbot, and stickleback.

41PACIFIC COASTAL MOUNTAINS

The Pacific Coastal Mountain subregion encompasses approximately 50,000 km^2 in the eastern half of the Southeast ecoregion. This subregion is delineated by the U.S.-Canada border to the east and the western hemlock/Sitka spruce forests to the west. The mountains range in elevation from sea level to a maximum of 4,500 m. Glaciers covered the mountains in the Pleistocene and persist over much of the area today.

The Pacific Coastal Mountains are underlain by Tertiary and Cretaceous intrusive rocks, and were shaped largely by Pleistocene and recent glaciation. The mountains are generally free from permafrost. Streams are short, steep, and swift. Where soils have accumulated they may be Lithic Cryorthents, Andic Cryumbrepts, Pergelic Cryumbrepts, Typic Cryumbrepts, Typic Haplocryods, Andic Humicryods, Lithic Humicryods, and Typic Humicryods (Gallant et al., 1995). These soils are developed primarily in gravelly till and colluvium.

The climate of the Pacific Coastal Mountains is influenced by maritime and continental factors. Elevation and geographic position play important roles in local weather patterns. The average annual precipitation ranges from 200 to 700 cm, including 500 to over 2,000 cm of snowfall. Average daily temperatures have not been recorded for this subregion, but remain below freezing throughout the year, over a majority of the subregion. Temperatures generally decrease with elevation, but this trend is variable given winds and terrain. (Gallant et al., 1995).

The majority of the Pacific Coastal Mountain subregion is covered by snow and glaciers throughout the year. Where vegetation has developed, it is characteristically dwarf scrub-shrub communities of mountain avens, berries, and willow. Some berries, grasses, and lichens may also be present. A small portion of the subregion may have tall scrub-shrub communities, including species such as willow, alder, and mosses. At lower elevations, paper birch and white spruce forests may be dominant before they transition into the temperate western hemlock-Sitka spruce environment of the coastal subregion.

Little is known about the invertebrates within the Pacific Coastal Mountains. Generally, invertebrates are few in harsh mountainous climates. A few species that are known to inhabit snowfields may be present in this subregion. Within the low-lying and moist habitats mosquitoes, flies, and gnats are likely. Other taxa present in the subregion could include trichoptera, coleoptera, hemiptera, arachnids, and dipterans. Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, and others. Major taxa in central Alaskan streams include stoneflies, mayflies, and dipterans (Brown, 1987; and Clay, 1973); these species are likely to inhabit the streams of the Pacific Coastal Mountains.

Most birds found in the Pacific Coastal Mountains are limited to lower elevations. With increasing distance westward and corresponding increases in elevation, the diversity and abundance decrease dramatically. Passerine species (song and perching birds) might include wheatear, water pipit, ptarmigan, crow, and raven because these species are able to inhabit harsh environments. Some hawks also may be found at moderate elevations where prey is available.

The lack of ground cover limits the numbers of small mammals. This, in turn, limits larger predatory mammals that inhabit the subregion. Shrews, voles, marmot, pika, and hares may be present. Dall sheep and mountain goats may be present in the mountains but are not numerous. Larger mammalian carnivores such as foxes and coyotes may also inhabit the subregion.

Anadromous fishes are common in the low-elevation rivers and streams of the coastal mountains. Anadromous species include chinook, coho, sockeye, pink, and chum salmon, and steelhead. Some larger lakes, ponds, and streams may support resident species including rainbow trout, lake trout, kokanee, char, grayling, whitefish, sucker, sheefish, burbot, and stickleback.

42SEWARD PENINSULA

The Seward Peninsula subregion occupies approximately 47,000 km^2 of the Seward Peninsula. This subregion covers the southwestern, western, central, and northeastern portions of the peninsula extending to the eastern edges of the Buckland River drainage. It excludes the forested lowlands found on the southeastern part of the peninsula surrounding Norton Bay. The northwestern half of St. Lawrence Island is also included within this region. The subregion is characterized by a mostly treeless landscape of coastal plains, rolling hills (< 500 m), and a few low mountains (< 1400 m).

The subregion is underlain by Paleozoic and Precambrian sedimentary, volcanic, and metamorphic bedrock. Highland areas may be Cenozoic uplifts of this parent material (Gallant et al., 1995). Permafrost is close to the surface and is an impermeable layer responsible for an abundance of surface water and surface distortions such as gelifluction lobes (terracing effect) and slightly uplifted ice wedge polygons. The rolling hills and valleys create numerous short, rapidly flowing streams. Lakes are common in the lowlands but rare in the hills and mountains.

Soils of the Seward Peninsula subregion are Histic Pergelic Cryaquepts, Pergelic Cryaquepts, Typic Cryochrepts, Pergelic Cryumbrepts, Lithic Cryorthents, and Pergelic Cryorthents (Gallant et al., 1995). Hillsides and ridges are mantled by a thin layer of gravelly soil over weathered bedrock. This condition allows high runoff during snowmelt and significant rainfall events. Valley and lower slope soils are generally developed on colluvial and alluvial sediments.

Although the peninsula is surrounded by water on three sides, there is little moderating effect on the subarctic climate. This is an area of transition between maritime and continental weather patterns, with strong and persistent winds blowing off the Bering and Chukchi Seas. Average daily temperatures range from –24°C in winter to 17°C during summer. Rainfall ranges from 25 to 50 cm in the lowlands up to 100 cm in the highlands. Snowfall varies from 100 to 250 cm across the subregion. The southern portions of the subregion may have warmer temperatures and higher precipitation than the northern parts. There are approximately 10 weeks of frost-free weather each summer.

Most of the subregion contains mesic (moist) grassland meadows and plateaus with dwarf shrub-low scrub communities occupying extensive areas on hills and lower mountain slopes. Tall scrub vegetation occurs along streams and active floodplains. There is also a small proportion of low-lying wet meadows. The dominant plant species in moist grasslands are tussock-forming sedges. The dwarf shrub-low scrub communities develop between the tussocks in drier areas and dominate in better-drained soils. These scrub-shrub communities include species such as mountain avens, sedges, dwarf arctic birch, resin birch, cranberry, blueberry, willow, crowberry, mosses, and lichens. Tall shrubs include willow, birch, and alder. The understory of the tall shrub community is frequently dense and may include oxytrope, vetch, dwarf fireweed, wormwood, bluejoint, and mosses.

Invertebrates are expected to be numerous on Seward Peninsula because of the large amounts of surface water and relatively warm summers. Mosquitoes are likely to be abundant, and it is assumed that species surviving in the Arctic ecoregion would be present. These include diptera trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, and others (copepods, rotifers, and cladocerans). The major taxa in a central Alaskan stream included stoneflies, mayflies, and dipterans (Brown, 1987; and Clay, 1973). Chironomids are likely to be the most numerous benthic invertebrates. Others such as steroptera, coleoptera and gastropoda may also occur (U.S. Navy, 1977; Holmquist, 1975; and Hobbie, 1973).

Some waterfowl and shorebirds inhabit the few lakes, ponds, or rivers within the subregion, but are less abundant on Seward Peninsula than in the surrounding coastline and lowland subregions. Passerine and other small upland bird species are most abundant and include sparrows, robins, thrushes, longspur, and snow bunting. Grouse, ptarmigan, and birds of prey such as rough-legged hawks, northern harriers, screech owls, ravens, and jeagers are also present.

Small mammals are abundant within the Seward Peninsula subregion. Species inhabiting this area primarily include foxes, hares, lemmings, voles, and shrews. Caribou range seasonally from lower to higher areas across the peninsula. Moose may be found locally in wet meadows and vegetation-filled streams and shorelines. Brown and black bears, weasels, and wolverines may also be found but are not abundant. Most of these species are residents within the subregion, but they may hibernate or migrate locally to optimum foraging grounds. The small mammals are critical to the ecosystem as prey items. Lemmings and voles are very important species on the coastal plain because many predators (mammals and birds) are dependent on them as a food source. When the numbers of lemmings drop, as they do on a cyclical basis, many predators die in the winter. Many remaining predators must switch to young birds and eggs as a dietary mainstay in the summer months. River otters, mink, muskrat, and beaver may be found in some of the rivers, streams, and lakes of the subregion.

Freshwater fishes are most abundant in the portions of streams and rivers near the coastline. Fishes may include inconnu; cisco; whitefish; salmon (coho, sockeye, chinook, pink and chum); grayling; char; pike; smelt; eulachon; blackfish; stickleback; and sculpin (DOI, 1979). Most of these species may be anadromous or have some tolerance to salt or brackish waters. Their migration is usually dependent on the freeze-thaw cycles of the rivers and bays of the subregion. Most of the lakes and ponds are less than 2 meters deep; therefore, they freeze solid in winter and do not support fish populations.

43SOUTHCENTRAL COASTLINE/ESTUARY

The coastline habitat is a narrow band along the coast of the Southcentral ecoregion, stretching from the entrance to Cook Inlet, east to the town of Redwood. It is a very productive area for many species of fish and wildlife, especially salmon. The habitat is variable, including biologically rich estuaries, lowland deltas, beaches, and barren or forested mountains rising from the water. This subregion provides important biological function, including resting, nesting, feeding, rearing, and/or migration staging grounds for many fish, marine mammals, waterfowl, seabirds, shorebirds, birds of prey, and songbirds. The seaside mountains and bays, inlets, lagoons, and estuaries within this subregion are of particular biological importance for their key roles in the staging and feeding of many of North America's major migratory bird and fish populations.

Most of the subregion lies between sea level and 1,200 m elevation. The terrain varies from coastal marshes or river deltas to steep, forested, or barren seaside mountains. Various geologic formations underlie the coastline in this ecoregion and include glacial deposits, as well as sedimentary and volcanic bedrock. Soils are highly variable within this subregion and may be shallow or deep, comprised of a wide range of materials from rock and gravel at the foot of the seaside mountains and cliffs to sand, silt, loess, and clay at the mouths streams and rivers.

The coast has maritime climate, dominated by the effects of the Gulf of Alaska. Winds are persistent and strong, frequently from the south or southwest. The severity of the winter is moderated by the Gulf of Alaska, but ice may cover much of Cook Inlet during several months of the winter. Average daily temperatures range from –15°C in winter to 18°C in summer. Precipitation occurs throughout the year, and it varies with elevation and distance inland. Annual averages vary from 35 to 135 cm. Annual snowfall averages 16 to 300 cm.

The abundance and type of vegetation in the coastline community is mainly determined by the presence and type of soil. Other factors include exposure to prevailing winds, ice, and wave action, and salinity. Beaches may be colonized by grasses such as beach rye, honckenya, beach plea, and groundsel. Seaside mountains may be barren, covered with bryophyte/lichen communities, have dwarf scrub-shrub habitats, or be forested with needleleaf or broadleaf tree species.

Eelgrass and ditch grass are important aquatic plants for many fish and wildlife. Brackish species include ditch grass, horned pondweed, alkali grasses, honckenya, fivefinger, arrow grass, and reed grasses. Phytoplankton (nannoplankton) and algae may also be found in the marine and estuarine areas. Marine algae species play an important role in the food chain of bird and fish species that inhabit islands and nearshore areas. Algae are present at various depths and are associated with various bottom structures. There are over 100 species of algae within at least three major taxa, including Chlorophycophyta, Phaeophycophyta, and Rhodophycophyta (Lebednik and Palmisano, 1977).

Invertebrates of the Gulf of Alaska are diverse. Polycheates, gammarids, and gastropods are likely to be most abundant. Shellfish potentially found in the bays and nearshore areas include king crab, tanner crabs, razor clams, and shrimp. Barnacles, snails, limpets, and starfish also are common. Other species may include representatives of the taxa Porifera (sponges); Cnidaria (hydrozoans); Ctenophora (comb jellies); Platyhelminthes (flatworms); Nemertea (ribbon worms); Mollusca (gastropods, bivalves, and cephalopods); Annelida (segmented worms); Sipuncula (peanut worms); Arthropoda (barnacles, shrimp, and crabs); Bryozoa (moss animals); Brachiopoda (lamp shells); Phoronida (phoronids); Echinodermata (echinoids, crinoids, etc.); and Chordata (thaliaceans) (Barr and Barr, 1983).

Birds commonly inhabiting the coastline community are predominantly migratory species, including seabirds, shorebirds, and waterfowl. These species may nest in the cliffs and beach ridges. However, a majority use this subregion as staging grounds and pass through to the north (spring) or south (fall) to preferred breeding or wintering habitats, respectively. Seabirds use the open water to varying degrees, some staying close to, and others spending a great deal of time off shore. These species include fulmar, shearwaters, storm-petrels, cormorants, gulls, terns, kittiwakes, murres, guillemots, murrelets, auklets, and puffins. Waterfowl are also present along the coastline, especially in estuaries. Northern pintail, scaup, teal, mallards, wigeon, harlequins, scoters, and mergansers are common. Shorebirds are also numerous, including sandpipers, plovers, godwits, and curlew. Spring migration occurs in April and May; nesting and rearing occur in May and June, respectively, and the birds depart for warmer climes by late September or October. The federally threatened spectacled eider and endangered Eskimo curlew may be found within this subregion. The proposed threatened Steller’s eider is also present.

Mammalian use of the coastline habitats generally is seasonal depending on the presence of food items. Species inhabiting this area include bears, foxes, weasels, ground squirrels, voles, mink, sea otters, seals, and walrus. Bears and foxes use the coastline seasonally as preferred prey become abundant. Where soil conditions allow burrowing, small mammal populations may develop in nearshore areas. However, sandy or gravelly conditions that are predominant along the shoreline often do not support burrows, and the small mammals frequently remain farther inland. Aquatic mammal use of the coastline also is seasonal. Feeding in the rich coastal waters and haulout of the rocky shores and islands are the most common activities. Whales such as beluga, gray, and orca whales may inhabit the nearshore areas of the coastline.

Cook Inlet and Prince William Sound are fish-rich waters. Fish of the subregion include all major salmon species, Arctic char, Dolly Varden, steelhead, lake trout, grayling, ling cod, halibut, rockfish, herring, and eulachon. Many of these species are migratory, some returning to rivers to spawn, and others retreating to deeper or warmer waters in the winter. Other species may include perch, sablefish, pollock, sole, flounder, lampreys, sharks, skates, smelts, lightfishes, viperfishes, lances, grenadier, sandfishes, ronquils, pricklebacks, and poachers (Simenstad et al., 1977).

The wood frog is the only amphibian that may be found in the subregion. No reptiles inhabit the coastline community.

44SOUTHEAST COASTLINE/ESTUARY

The coastline habitat is a large portion of the Southeast ecoregion because of the large number of small islands and fjords that reach inland along the eastern Gulf of Alaska coast. The habitat is variable, including biologically rich estuaries, lowland deltas, beaches, forested mountains rising from the water, and glaciers draining and calving into the ocean. This subregion provides important biological function, including resting, nesting, feeding, rearing, and/or migration staging grounds for fish (especially salmon and steelhead); waterfowl; seabirds; and shorebirds.

The subregion lies between sea level and 500 m elevation. The terrain varies from low-lying coastal estuaries and river deltas, to steep, forested seaside mountains. The coastline is underlain by Mesozoic volcanic and intrusive rock, and Mesozoic and Paleozoic sedimentary rock. Soils are highly variable within this subregion and may be shallow or deep, with a wide range of materials, from rock and gravel at the foot of the seaside mountains and cliffs to sand, silt, alluvium, loess, and clay along beaches and at the mouths of streams and rivers.

The climate of the coast is maritime, dominated by the effects of the Gulf of Alaska. Winds are persistent and strong, frequently from the south or southeast. The severity of the winter is moderated by the maritime influence, and very little ice forms over the ocean water. Average daily temperatures vary from –3°C during winter to 18°C in summer. Precipitation occurs throughout the year and is highly variable depending on elevation and distance inland. Annual averages vary from 135 to 390 cm, with annual average snowfall of 80 to 100 cm.

The type and abundance of vegetation in the coastline community depend largely on the type of soil. Other factors include the exposure to prevailing winds, wave action, and salinity. Sandy beaches may be colonized by grasses, such as beach rye and other species, such as honckenya, beach plea, and groundsel. Seaside mountains and hills are usually forested with needleleaf tree species, including western hemlock and Sitka spruce.

The waters in this region are extremely productive. Eelgrass is an important aquatic plant for many fish and wildlife resources. Brackish grasses may include ditch grass, horned pondweed, alkali grasses, honckenya, fivefinger, maritime arrow grass, and reed grass. Phytoplankton (nannoplankton) and algae may also be found in the marine and estuarine areas. Marine algae species play an important role in the food chain of bird and fish species inhabiting the islands and nearshore areas. The algae are present at various depths and associated with various bottom substrates (i.e., rocks, sand, or silt). There may be over 100 species of algae within at least three taxonomic groups, including Chlorophycophyta, Phaeophycophyta, and Rhodophycophyta (Lebednik and Palmisano, 1977).

Shellfish potentially found in the estuarine climate of the bays and nearshore areas include king crab, tanner crabs, razor clams, and shrimp. Barnacles, snails, limpets, and starfish also are common. Other species present include representatives of the taxa Porifera (sponges); Cnidaria (hydrozoans); Ctenophora (comb jellies); Platyhelminthes (flatworms); Nemertea (ribbon worms); Mollusca (gastropods, bivalves, and cephalopods); Annelida (segmented worms); Sipuncula (peanut worms); Arthropoda (barnacles, shrimp, and crabs); Bryozoa (moss animals); Brachiopoda (lamp shells); Phoronida (phoronids); Echinodermata (echinoids, crinoids, etc.); and Chordata (thaliaceans and allies) (Barr and Barr, 1983).

Birds commonly inhabiting the coastline community include both migratory and resident species, including raptors, seabirds, shorebirds, and waterfowl. Seabirds, shorebirds, and waterfowl may nest along the shoreline. However, the majority use this subregion as staging grounds and pass through to the north (spring) or south (fall) to preferred breeding or wintering habitat, respectively. Seabirds include fulmar, shearwaters, storm-petrels, cormorants, loons, grebes, gulls, terns, kittiwakes, murres, guillemots, murrelets, auklets, and puffins. Waterfowl are present along the coastline, especially in the estuaries of the subregion. Canada geese, northern pintail, scaup, teal, mallards, wigeon, harlequins, goldeneye, bufflehead, scoters, and mergansers are common. Shorebirds are also numerous, including sandpipers, plovers, godwits, and curlew. Nesting and rearing occur in May and June, respectively, and the migratory birds depart for warmer climates by late October. Raptors such as eagles, sharp-shinned hawks, and kestrels are common in the forests of the coastline. Crows and ravens also are present.

Mammalian use of the coastline habitats is seasonal. Species inhabiting this area include bears, foxes, weasels, ground squirrels, voles, mink, sea otters, and seals. Foxes range over wide areas and use the shoreline area intermittently. Where soil conditions allow burrowing, small mammal populations may develop in nearshore areas. However, the sandy/gravelly or mountainous conditions generally do not support burrows, and the small mammals frequently remain farther inland. Aquatic mammal use of the coastline is variable. Mink may remain within a small area such as an estuary when food and cover are plentiful, but sea otters and seals range over wide areas and may use a particular feeding or resting area for short periods. Whales such as beluga, gray, and orca whales may briefly inhabit the nearshore areas of the coastline as they migrate north or south.

The entire Alexander Archipelago is a fish-rich area. Fish of the subregion include all major salmon species, steelhead, ling cod, halibut, rockfish, herring, and eulachon. Many of these species are migratory, some returning to rivers to spawn, and others retreating seasonally to deeper or warmer ocean waters. Other species may include perch, sablefish, pollock, sole, flounder, lampreys, sharks, skates, smelts, lightfishes, viperfishes, lances, grenadier, sandfishes, ronquils, pricklebacks, and poachers (Simenstad et al., 1977).

45SOUTHWEST COASTLINE/ESTUARY

This coastline habitat is a narrow band stretching from the Kanektok River in Kuskokwim Bay, around the Alaska Peninsula to Cape Douglas at the entrance to Cook Inlet. It also includes the coast of Kodiak, Afognak, and Shuyak Islands. It is one of the most productive coastlines in the world for many species of fish, especially salmon. The habitat is variable, including biologically rich estuaries, lowland deltas, beaches, and barren, rugged seaside cliffs. This subregion provides important biological function, including resting, nesting, feeding, rearing, and migration staging grounds for many fish, marine mammals, waterfowl, seabirds, and shorebirds.

Most of the subregion lies between sea level and 700 m elevation. Various geologic formations underlie the coastline in this ecoregion, including glacial moraine and volcanic deposits. Soils are usually thin and are comprised of broken rock, gravel, sand, or silt.

The coastal climate is maritime, dominated by the effects of the Bering Sea and the Gulf of Alaska. Winds are persistent and strong, frequently from the west or southeast. The severity of the long winter is moderated by the large bodies of water. Ice may cover nearshore coastal waters during several months of the winter. Average daily temperatures vary between northern and southern portions of the ecoregion but reach –15°C in winter and up to 18°C in summer. Precipitation occurs throughout the year and is highly variable depending on elevation and distance inland. Average annual precipitation ranges from 30 cm in the lowlands to over 400 cm in the Alaska Peninsula Mountains. Annual snowfall averages 55 to 150 cm.

The presence and type of vegetation in the coastline community is mainly determined by the steepness of the banks/cliffs; the amount of exposure to prevailing winds, ice, and wave action; the type of soil/sediment; and salinity. Beaches may be dominated by grasses such as beach rye, and other species such as honckenya, beach plea, and groundsel. Cliffs are generally sparsely vegetated with bryophytes, lichens, and some grasses or dwarf scrub-shrub species. The waters in this region are extremely productive, supporting a rich diversity and high biomass of plankton, shellfish, fish, seabirds, and marine mammals. Brackish species include ditch grass, pondweed, alkali grass, honckenya, fivefinger, arrow grass, and reed grass. Some marine aquatic plants important to bird species include eelgrass and ditch grass. Phytoplankton (nannoplankton) and algae may also be found in the marine and estuarine areas. Marine algae species play an important role in the food chain of bird and fish species inhabiting the islands and nearshore areas. The algae are present at various depths and associated with particular bottom structure. There are over 100 species of algae within at least three taxonomic groups. These include Chlorophycophyta, Phaeophycophyta, and Rhodophycophyta (Lebednik and Palmisano, 1977).

Invertebrates of the Bering Sea and Gulf of Alaska are diverse and abundant. Polycheates, gammarids, and gastropods are likely to be most abundant. Shellfish potentially found in the bays, inlets, and lagoons include king crab, tanner crabs, razor clams, and shrimp. Barnacles, snails, limpets, and starfish also are common. Other species present include representatives of the groups Porifera (sponges); Cnidaria (hydrozoans); Ctenophora (comb jellies); Platyhelminthes (flatworms); Nemertea (ribbon worms); Mollusca (gastropods, bivalves, and cephalopods); Annelida (segmented worms); Sipuncula (peanut worms); Arthropoda (barnacles, shrimp, and crabs); Bryozoa (moss animals); Brachiopoda (lamp shells); Phoronida (phoronids); Echinodermata (echinoids, crinoids, etc.); and Chordata (thaliaceans and others) (Barr and Barr, 1983).

Migratory seabirds, shorebirds, and waterfowl are the predominant species inhabiting the Bristol Bay and Alaska Peninsula coastal area. The seabirds frequently use the cliffs and beach ridges as nesting areas. These shore-dependent birds use the open water to varying degrees, some staying close to shore and others spending a great deal of time at sea. Seabird species include fulmar, shearwaters, storm petrels, cormorants, gulls, terns, kittiwakes, murres, guillemots, murrelets, auklets, and puffins. Many of these, and other seabirds, nest only along the Alaska coast and are sensitive to human intrusion during the nesting period. Many species of waterfowl are also present along the coastline, especially in the rich estuaries of the region. Northern pintail, scaup, and teal are the most numerous, but scoters, mallards, wigeon, harlequins, and mergansers may also be found. Shorebirds are also numerous, including sandpipers, plovers, godwits, and curlew. Many of these birds use the coastline as a staging area before moving farther north (in the spring) or south (in the fall) to their preferred nesting or winter areas. Nesting and rearing occur in June and July, respectively, and the birds depart for warmer climes by mid- to late September. The federally threatened spectacled eider, the endangered Eskimo curlew, and the proposed threatened Steller's eider are all present in this subregion.

Mammalian use of the coastline habitats generally is seasonal, depending on the presence of pack ice and snow cover. Species inhabiting this area include caribou, moose, foxes, weasels, ground squirrels, voles, mink, sea otters, seals, and walrus. Caribou are only occasional users of the coastline habitat, preferring to remain in richer grassy lowlands or open forested areas. Foxes may be present year-round, but their presence is directly linked to the presence of small mammals or other key prey items. Where soil conditions allow burrowing, small mammal populations may develop in nearshore areas. However, the sandy/gravelly soils generally do not support burrows, and the small mammals usually remain farther inland. Use of the coastline by small mammals is variable, with feeding and haulout because the most common activities. Beluga, gray, and orca whales may inhabit the nearshore areas of the coastline.

Bristol Bay and the surrounding regions are some of the world's richest fish waters. Fish of the region include all major salmon species, cod (arctic and saffron), capelin, Arctic char, Dolly Varden, steelhead, lake trout, grayling, ling cod, halibut, rockfish, herring, and eulachon. Many of these species are migratory, returning to rivers to spawn or retreating to deeper, warmer, or flowing waters during the winter when ice covers shoreline waters. Other common species may include perch, sablefish, pollock, sole, flounder, lampreys, sharks, skates, smelts, lightfishes, viperfishes, lances, grenadier, sandfishes, ronquils, pricklebacks, poachers, and others (Simenstad et al., 1977).

46SUBARCTIC COASTAL PLAIN

This subregion consists of a fairly monotypic habitat of wet grassland meadows. The terrain consists of flat, poorly drained coastal plains below 120 m in elevation. Permafrost is close to the surface and is an impermeable layer responsible for an abundance of surface water in the subregion. The subregion is predominantly underlain by intrastratified alluvial and marine sediments. However, Quaternary volcanic rocks occur on St Lawrence Island, and Cretaceous volcanic rocks occur in the Selawik Basin (Gallant et al., 1995). These bedrock units are locally overlain by silty and sandy alluvial deposits. Histic Pergelic Cryaquepts and Pergelic Cryofibrist soils are developed on the bedrock and overlying deposits; these soils are shallow and constantly wet (Gallant et al., 1995).

Within the Northwest ecoregion, the Subarctic Coastal Plain climate is generally maritime, dominated by the cold and frequently ice-covered Chukchi and Bering Seas. Average daily temperatures range from –25°C in winter to 17°C in summer. Rainfall averages 25 to 30 cm with 100 cm of snow. The southern portions of the subregion may have warmer temperatures and higher precipitation. Summers are short and mild, and winters are very cold. Ice begins covering the lakes, ponds, and rivers in October, freezing many of them solid until the spring thaw in May.

Vegetation of the Subarctic Coastal Plain is dominated by graminoid meadows (grassy tundra) similar to those found in the Arctic Coastal Plain. The dominant plant species in wet meadows are sedges and mosses (especially *sphagnum* spp.). Horsetails and rushes may also occur. Drier soils such as peat mounds, sand dunes, and volcanic soils allow shrubs to dominate the landscape in limited areas. Dwarf scrub-shrub communities may include crowberry; Labrador tea; berries (cranberry, huckleberry, and blueberry); alpine azalea; and dwarf willow. Lichens may also be found on drier substrates. The vegetation communities are all very low lying (< 25 cm), providing an open expanse across the subregion. Within the many lakes, planktonic; submergent (pondweed, bur reed, bottom algae, and buttercup); and emergent species (pendant grass and marestail); floating vegetation (duck weed); and bottom algae may be present (Holmquist, 1975). Generally, production within aquatic systems is high during the warm summer months.

Invertebrates, wildlife, and fish inhabiting the Subarctic Coastal Plain are well-suited to the wet conditions. Many vertebrate species migrate to avoid the harsh winters. The diversity of species is limited by the monotypic vegetation; however, abundance of particular species is high.

Terrestrial invertebrates inhabiting the subregion include diptera, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Aquatic invertebrates of the lakes and ponds include copepods, rotifers, and cladocerans. The primary benthic invertebrates are chironomids; however, dipterans, oligochaetes, steroptera, coleoptera, and gastropoda may also occur (U.S. Navy, 1977;

Holmquist, 1975; and Hobbie, 1973). The peak hatches occur in concert with the nesting and hatching of many of the inland bird species that depend on the invertebrate as food.

Birds found in the Subarctic Coastal Plain include herbivores, omnivores, and carnivores. Waterfowl and shorebirds are the most numerous species within the subregion, and they begin arriving in mid-April and May. The coastal plains are irreplaceable nesting, resting, and staging grounds for many of the waterfowl and shorebird species. A large number of migratory birds use this coastline as a staging area before moving farther north (in the spring) or south (in the fall) to their preferred nesting or winter areas. Nesting and rearing occur in June and July, respectively, and the birds depart for warmer climates by mid- to late September. The most common waterfowl and shorebirds include swans, geese, brant, eider, northern pintail, scaup, teal, loons, plover, phalaropes, godwits, snipe, terns, and sandpipers. Sandhill cranes are also found, and the federally threatened, spectacled eider and endangered Eskimo curlew inhabit the subregion. Northern harriers, rough-legged hawks, short-eared owls, ravens, jeagers, and shrikes are predatory birds found within the Subarctic Coastal Plain. Gallinaceous birds are common and include grouse and ptarmigan. Passerine and other small bird species are numerous, including robins, thrushes, sparrows, pipits, longspur, and snow bunting.

Mammals are abundant within the Subarctic Coastal Plain. Species inhabiting this area include brown and black bears, moose, caribou, foxes, weasels, lemmings, voles, and shrews. Most of these species are resident, but may hibernate or migrate locally to optimum winter foraging grounds. The small mammals are critical to the ecosystem as prey items. Lemmings may be the most important mammals on the coastal plain because several predators (mammals and birds) depend on them as a food supply. In years when there are few lemmings, many predators must switch to young birds and eggs as a dietary mainstay in the summer months. River otters, mink, muskrat, and beaver may be found in some of the rivers, streams, and lakes of the subregion.

Freshwater fishes such as inconnu (sheefish); cisco; whitefish; salmon (coho, pink, and chum); grayling; char; pike; smelt; eulachon; blackfish; stickleback; and sculpin may be found in rivers and/or lakes of the Subarctic Coastal Plain (DOI, 1979). Most of these species may be anadromous and have some tolerance to salt or brackish waters. Their migration is usually dependent on the freeze-thaw cycles of the rivers and bays of the subregion. Most of the lakes and ponds in the coastal plain are less than 2 meters deep and therefore freeze solid in winter and do not support fish populations. Water quality in smaller lakes and ponds is usually poor, with low nitrogen and oxygen content; thus, they rarely support large populations of fish.

Wood frogs may inhabit the Subarctic Coastal Plain. No reptiles are found in the this subregion.

47WRANGELL MOUNTAINS

The Wrangell Mountains extend west-northwest from the U.S.-Canada border to the Alaska Range. These mountains are underlain by Cenozoic volcanic bedrock and are extensively covered by ice fields and glaciers. The mountains range in elevation from 600 m along valley floors to 4,880 m at the mountain crests, but most peaks are less than 3,900 m. The terrain is very rugged with deep valleys, steep mountainsides, and scarce vegetation. Permafrost is discontinuous. Streams in the subregion have steep gradients with their headwaters at the fringes of the glaciers and snowfields.

The Wrangell Mountain soils are generally thin and developed from stony or gravelly colluvium on the slopes, or from glacial till and alluvium in the valleys. Principal soil types are Lithic Cryorthents, Typic Cryorthents, Pergelic Cryochrepts and Pergelic Cryumbrepts (Gallant et al., 1995). Valley soils may be poorly drained.

The climate of the Wrangell Mountains is mainly continental. Average temperatures range from –34°C in winter to 22°C in summer. Temperatures generally decrease with increasing elevation, but this trend is variable given winds and terrain. Mean annual precipitation is approximately 41 cm, with 175 cm of snowfall. Higher elevations may receive 203 cm precipitation with 255 cm of snowfall (Gallant et al., 1995).

The Wrangell Mountains are mostly devoid of vegetation. Dwarf scrub occurs in some areas where soils have accumulated in windswept mountainous areas, and tall scrub is present along drainages and on floodplains in the valleys. The dominant dwarf scrub plant species include mountain avens, low-lying berry bushes, dwarf willow, saxifrage, anemone, and lichens. Tall scrub communities include willows and alder with an understory of grasses and mosses. Forests of spruce, birch, and aspen are found in the lowest, northernmost portions of the subregion. These forests are similar to those found in the interior uplands subregion (Gallant et al., 1995).

Little is known about the invertebrates within the Wrangell Mountains. Generally, invertebrates are scarce in harsh mountainous climates. A few species are known to inhabit snowfields and may be present in this subregion. Within the low-lying and moist habitats, mosquitoes, flies, and other species may be present. Aquatic invertebrates, including stoneflies, mayflies, and other dipterans (Brown, 1987; and Clay, 1973); steroptera; coleoptera; and gastropoda may be present in the valley rivers and streams, especially at lower elevations.

Most birds found in the Wrangell Mountains are limited to lower elevations. With increasing distance northward and corresponding increases in elevation, the diversity and abundance decrease dramatically. Passerine species (song and perching birds) abundance and diversity is low. Wheatear, water pipit, ptarmigan, and raven are the species inhabiting the highest elevations. Some hawks also may be found nesting in the cliffs within short distances to habitats that support their prey.

Small mammals are uncommon in the high elevation mountains, which limits the number of larger predatory mammals in these regions. On the valley floors shrews, voles, and lemmings are present where vegetation is well developed. Marmot, pika, and hares may inhabit more rocky substrates above the valley floors. Caribou are not common within the Wrangell Mountains but may be found seasonally in the valleys at the northern extent of the mountains. Dall sheep are present, but not numerous. Mammalian carnivores such as wolves and coyotes are also present, hunting in the valleys and foothills of the mountains.

Some tributaries of the upper reaches of the Tanana River are located in the Wrangell Mountains. These tributaries may support anadromous species such as salmon. Resident species are also possible including, northern pike, grayling, whitefish, sucker, inconnu (sheefish), burbot, and stickleback.

The wood frog is the only amphibian that may be found in the subregion. No reptiles inhabit the Wrangell Mountains

48YUKON FLATS

The Yukon Flats subregion is a 33,000 km^2 marshy basin encompassing the northernmost portion of the Yukon River and the lower stretches of the Porcupine River. This area is characterized by forested lowlands, wet grassland meadows, abundant surface water, braided and meandering streams and oxbows, and many thaw lakes. This subregion is similar (except for weather) to the Interior Bottomlands found in the southern and western portions of the Interior ecoregion. The central portion of the area is flat with elevations ranging from 90 m near the center of the subregion to 250 m at the edges of the basin. Quaternary alluvial deposits overlay much of the area with lesser coverage by aeolian silt and sands. Permafrost is present across the flats except under rivers and larger lakes.

Principal soils are Histic Pergelic Cryaquepts, Pergalic Cryoquepts, Aquic Cryochrepts, and Pergelic Cryochrepts. Most of these soils are formed from alluvium and loess and are frequently overlain by peat (Gallant et al., 1995).

The climate of the highlands is considered continental. Summer temperatures are often higher than surrounding subregions, and winter temperatures are colder. The average daily minimum and maximum temperatures are –34°C and 22°C, respectively. Extreme temperatures can be much colder or hotter. The highest temperature recorded north of the Arctic Circle (38°C) was documented within the Yukon Flats subregion. Annual precipitation is low, averaging 17 cm with 115 cm of snow. Twenty-four hours of darkness in winter, combined with extreme cold temperatures, slows biological process in the area, but 24 hours of light and very warm temperatures in the summer allow very high terrestrial and aquatic primary productivity.

Vegetation within Yukon Flats is dominated by needleleaf, broadleaf, and mixed forests with intermixed tall scrub-shrub communities and wet grassy meadows. Needleleaf forest species include white spruce in drier soils and black spruce in poorly drained areas. Broadleaf species include quaking aspen and balsam poplar. The tall scrub-shrub community occurs both as an understory to the dominant forests, and as a separate vegetation stand where needleleaf and broadleaf species are absent. Constituents of the tall scrub-shrub include resin birch, alder, and willow, and an understory of prickly rose, Labrador tea, and berries. The forest herb layer frequently includes bluejoint, bluebell, horsetail, and mosses. The wet meadow species principally are sedges, horsetail, and mosses.

Invertebrates are numerous in the Yukon Flats subregion because of the warm summer temperatures, high productivity, and large amounts of surface water. Mosquitoes, gnats, and blackflies very abundant. Other types of invertebrates that are commonly present include diptera, trichoptera, coleoptera, hemiptera, and arachnids (Hurd, 1958; Bohnsack, 1968; Usinger, 1960; Bunnel, 1975; and U.S. Navy, 1977). Freshwater aquatic/benthic invertebrates might include plecoptera, ephemeroptera, diptera, trichoptera, collembola, hymenoptera, oligochaeta, lepidoptera, and others (copepods, rotifers, and cladocerans). The major taxa in a central Alaskan stream includes stoneflies, mayflies, and other dipterans (Brown, 1987; and Clay, 1973). Chironomids are likely to be the most numerous benthic invertebrates; however, steroptera, coleoptera and gastropoda are also common (U.S. Navy, 1977; Holmquist, 1975; and Hobbie, 1973).

Yukon Flats is one of the most important waterfowl breeding areas in the world. It serves as a key staging area for other waterfowl heading north in the spring and south in winter. The principal species include scaup, pintail, scoters, wigeon, mallards, shovelers, green-winged teal, and canvasbacks. Swans, geese, loons, grebes, and sandhill cranes also are common. In years of drought on the Canadian plains, waterfowl that normally nest in Canada may migrate to the Yukon Flats subregion to nest. Birds of prey such as sharp-shinned hawk, red-tailed hawk, kestrel, raven, great-horned owl, and short-eared owl are all common to the area, and the endangered American peregrine falcon inhabits the area. Spruce grouse, ruffed grouse, and ptarmigan are found in drier areas. Passerines and other small birds are also common in the subregion and include gray jay, chickadees, robins, thrushes, warblers, redpoll, pipits, and sparrows, among others. Nesting and rearing are likely to occur in June and July, respectively, and migratory birds depart for warmer climates by late September and early October.

Mammals inhabiting the forested areas include brown and black bears, wolves, wolverine, weasels, marten, hares, marmot, squirrels, voles, and shrews. Moose are abundant in the subregion, and the Porcupine and Fortymile caribou herds overwinter in the Yukon Flats. Many of these species are resident year-round, but may hibernate or migrate locally to optimum foraging grounds. Aquatic mammals such as muskrat, mink, and beaver are common in the myriad of water bodies in the subregion.

Anadromous and resident fishes are abundant. Anadromous species include chinook, coho, and chum salmon that migrate farther upstream (a thousand miles or more) than any other salmon in the world. Resident species are northern pike, grayling, whitefish, sucker, sheefish, burbot, and stickleback.

Wood frogs are the only amphibian in the Yukon Flats subregion. There are no reptiles in this subregion.

49YUKON-KUSKOKWIM DELTA COASTLINE/ESTUARY

This coastline habitat is a narrow band along the coast of the Yukon-Kuskokwim Delta ecoregion. It is irreplaceable to many species of fish and wildlife, especially cliff-nesting birds. The habitat is variable, including estuaries, lowland deltas, and barren, rugged cliffs rising from sea level to heights of 700 m. This subregion provides important biological function, including resting, nesting, feeding, rearing, and migration staging grounds for many of the fish, marine mammals, waterfowl, seabirds, and shorebirds of the Arctic. Of particular biological importance within this subregion are the seaside cliffs and bays, inlets, lagoons, and estuaries.

Most of the subregion lies between sea level and 500 m elevation. The region is underlain by Mesozoic and Paleozoic sedimentary and volcanic bedrock mantled by vast tracts of alluvium and loess. Soils are usually thin and include Histic Pergelic Cryaquepts, Pergelic Cryaquepts, Aquic Cryochrepts, Pergelic Cryoquepts, Typic Cryochrepts, Typic Cryorthents, and Pergelic Cryumbrepts (Gallant et al., 1995).

The coastal climate is maritime, dominated by the effects of the Bering Sea. Winds are persistent and strong, frequently from the northwest or southwest. Long winters are characteristic of the subregion, with ice covering the coastal waters several months of the year. Temperatures vary between northern and southern portions of the ecoregion but average –16°C in winter to 17°C in summer. Generally, there are about three months of frost-free weather each year. Precipitation occurs mainly in late summer and early fall, and averages 50 cm with up to 150 cm of snow.

The presence of vegetation in the coastline community is mainly determined by the steepness of the banks/cliffs; the amount of exposure to prevailing winds, ice, and wave action; the type of soil/sediment; and salinity. Beaches may be dominated by grasses, such as beach rye, and other species, such as honckenya, beach plea, and groundsel. Cliffs are generally sparsely vegetated with bryophytes, lichens, and grass clumps where soils are present. Brackish species include ditch grass, pondweed, alkali grass, honckenya, fivefinger, maritime arrow grass, and reed grass. Some marine aquatic plants found in the subregion that are important to bird species include eelgrass and ditch grass. Phytoplankton (nannoplankton) and algae may also be found in the marine and estuarine areas. Marine algal species are more common toward the southern portion of the ecoregion. The plants within the Yukon-Kuskokwim Delta coastline community play an irreplaceable role in support of shorebirds, waterfowl, and marine mammals that nest or migrate through this subregion each year.

Invertebrates of the Yukon-Kuskokwim Delta coastal waters are diverse and abundant. In muddy-bottomed estuaries, pelecypods, priapulids, polychaetes, tunciates, isopods, mysids, and amphipods are common. Rocky- and gravelly-bottomed waters provide habitat for polycheates, gammarids, and gastropods (O'Clair, 1977). Shellfish include crab, clams, and shrimp. Barnacles, snails, limpets, and starfish also are common. Other species include representatives of Porifera (sponges); Cnidaria (hydrozoans); Ctenophora (comb jellies); Platyhelminthes (flatworms); Nemertea (ribbon worms); Mollusca (gastropods, bivalves, and cephalopods); Annelida (segmented worms); Sipuncula (peanut worms); Bryozoa (moss animals); Brachiopoda (lamp shells); Phoronida (phoronids); Echinodermata (echinoids, crinoids, etc.); and Chordata (thaliaceans and allies) (Barr and Barr, 1983). Zooplankton such as cladocerans and copepods are also present. These species provide a critical production and decomposition role within estuarine and nearshore ecosystems, and serve as the food base for many higher trophic-level species.

Birds inhabiting the coastline community are predominantly migratory species that use the cliffs and beach ridges as nesting areas. They begin arriving in mid-April and May. A large proportion of the birds use this coastline as a staging area before moving farther north (in the spring) or south (in the fall) to their preferred nesting or winter areas. Nesting and rearing occur in June and July, respectively, and the birds depart for warmer climes by mid- to late September. Migratory birds found along the coastline primarily include seabirds, waterfowl, and shorebirds. The most common seabirds include kittiwakes, auklets, storm petrels, murres, cormorants, and puffins. Many of these nest only along the Alaska coast and are sensitive to human intrusion during the nesting period. The federally threatened spectacled eider and endangered Eskimo curlew may be found within this subregion. Many species of waterfowl are also present along the coastline, especially the rich estuaries of the Yukon and Kuskokwim Rivers. Northern pintail, scaup, and teal are the most numerous, but scoters, mallards, wigeon, harlequins, and mergansers may also be found. Shorebirds of the subregion include sandpipers, plovers, godwits, and curlew.

Mammalian use of the coastline habitats generally is seasonal, depending on the presence of pack ice and snow cover. Species inhabiting this area include muskox (on Nunivak Island), foxes, weasels, mink, ground squirrels, voles, sea otters, seals, and walrus. Small mammal populations may develop in localized nearshore areas where soil conditions allow for burrowing and tunnel stability. Caribou and moose may be found locally within this subregion. The most common aquatic mammal uses of the coastline are feeding and haulout.

The estuaries, bays, lagoons, and nearshore waters provide habitat for anadromous and resident fish. Fish of the Bering Sea that are found along the coastline of the Yukon-Kuskokwim Delta include all major salmon species, cod (Arctic and saffron), capelin, Arctic char, Dolly Varden, steelhead, ling cod, halibut, rockfish, herring, and eulachon. Many of these species are migratory in some fashion, some returning to rivers to spawn, and others retreating to deeper, warmer, or flowing waters during the winter when ice covers the nearshore areas. Other common species include perch, sablefish, pollock, sole, flounder, lampreys, sharks, skates, smelts, lightfishes, viperfishes, lances, grenadier, sandfishes, ronquils, pricklebacks, poachers, and others (Simenstad et al., 1977).

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APPENDIX D

DEVELOPMENT OF DEFAULT ASSESSMENT ENDPOINT AND PRIMARY INDICATOR SPECIES FOR ALASKAN ECOREGIONS

TABLE OF CONTENTS

Page

LIST OF TABLES

Table No.

LIST OF TABLES (cont.)

Table No.

LIST OF FIGURES

Figure

ABBREVIATIONS AND ACRONYMS

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADPH	Alaska Department of Public Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
NOAA	National Oceanic and Atmospheric Administration
OIW	Oceanographic Institute of Washington
USFWS	U.S. Fish and Wildlife Service

APPENDIX D

DEVELOPMENT OF DEFAULT ASSESSMENT ENDPOINT AND PRIMARY INDICATOR SPECIES FOR ALASKAN ECOREGIONS

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DEVELOPMENT OF DEFAULT ASSESSMENT ENDPOINT AND PRIMARY INDICATOR SPECIES FOR ALASKAN ECOREGIONS

51INTRODUCTION

This appendix documents the development and selection of appropriate, preapproved, default assessment endpoints and primary indicator species for Alaskan ecoregions to be used in the performance of ecological risk assessments (ERAs) in Alaska. The overall goal was to develop defaults that are scientifically sound, practical to implement, and address the concerns of state and federal agencies and other diverse stakeholders. The ecoregions for which defaults were developed included:

< Aleutian Islands
< Arctic Slope
< Interior
< Northwest
< Southcentral
< Southeast
< Southwest
< Yukon - Kuskokwim Delta

See Appendix A for details of the ecoregion selection process.

The selection process for default assessment endpoints and indicator species involved combining the results from two parallel tasks for each of these eight Alaskan ecoregions. These tasks involved determining societal/cultural values to be protected, and classifying plants, invertebrates, fishes, and wildlife into functional groups. A functional group is a set of similar species that are likely to have similar exposures to contaminants because they have similar foraging habits and are from the same trophic level (i.e., have similar diets). Generally, it is also assumed that they have similar toxicological responses, if exposed to the same chemicals in a similar fashion.

Societal and cultural value research was completed for eight Alaskan ecoregions (see Section D.2). This included determination of the species of concern to Native and non-Native cultures through telephone interviews, written correspondence, and literature reviews (see Tables D.1-1 through D.1-8), as well as identification of rare, threatened, or endangered species (Tables D.2-1 through D.2-8). Of the 64 cultural, commercial, environmental, and government groups that were contacted as potential stakeholders, the following groups provided specific input on societal and cultural values:

- The Association of Village Council Presidents
- Athabascan Tribal Government
- Maniilaq Association
- Tanana Chiefs Conference
- Arctic Slope Native Association
- U.S. Department of Agriculture Forest Service
- Alaska Community Action on Toxics
- The Alaska Trappers Association.

A Working Group was also established to provide detailed technical input for determination of the ecoregions and the default assessment endpoints and indicator species. The members were representatives of the following agencies:

- ADEC
- Alaska Department of Fish and Game (ADFG)
- Alaska Division of Public Health (ADPH)
- National Oceanic and Atmospheric Administration (NOAA)
- United States Environmental Protection Agency (EPA)
- United States Fish and Wildlife Service (USFWS)
- United States Navy (Navy)

Members of the Ecoregions Working Group also provided input on societal values.

Detailed descriptions of the ecology of each Alaskan ecoregion were prepared (see Section D.3), including species lists. The species in each ecoregion were organized into functional groups (see Tables D.3-1 through D.3-8):

- By type (e.g., vegetation, invertebrate, fish, amphibian, bird, or mammal).

- By the species' primary foraging strategy, which included consideration of foraging habitat association (e.g., aquatic, semiaquatic/benthic, terrestrial, or epiphytic) and trophic level (primary producer, herbivore, detritivore, invertevore, or carnivore).

- Final subdivision by foraging habitat qualifier (e.g., fish-eating, marine, estuarine, freshwater, sediment, or soil).

Information from these two parallel tasks was combined to select a draft list of default assessment endpoints and associated primary indicator species (see Section D.4 and Tables D.4-1 through D.4-8) in accordance with ERA guidance (U.S. Environmental Protection Agency, 1998). An overview of this process is presented in Figure D.1-1. The details of this process are presented in the following sections.

52DETERMINING SOCIETAL VALUES TO BE PROTECTED

Certain fairly universal societal values were defined relative to protection of natural resources. These values must be considered and are frequently prescribed in ERA guidance. Societal values that are frequently used to focus ERAs include:

1) Protecting species used for subsistence.
2) Protecting species of ceremonial importance.
3) Protecting species with commercial value.
4) Protecting species that provide recreational opportunity.
5) Protecting regulated species (rare, threatened, or endangered species; marine mammals; and migratory birds) considered especially sensitive to anthropogenic impacts.
6) Protecting ecosystem health; that is, protecting both a sufficient number of individuals within a species to maintain a healthy population (abundance) and the number of different species (diversity).

Species associated with subsistence, ceremonial, commercial, recreational, and regulatory values in each ecoregion were defined and are listed in Tables D.1-1 through D.1-8. Tables D.2-1 through D.2-8 list regulated species for each ecoregion. Societal values (and associated species) that were identified and are related to the unique cultures located within each ecoregion are presented in more detail within the following subsections. To protect ecosystem health, it is generally necessary to protect each biological functional group represented at a particular site. If each functional group is protected, the overall integrity (function and value) of the ecosystem should also be protected. Functional groups are defined by ecoregion in Section D.3, and species within each functional group are listed in Tables D.3-1 through D.3-8.

52.1 Aleutian Islands

For the Aleutian Islands ecoregion (Table D.1-1), information on cultural values was obtained from discussions with representatives of the Aleutian/Pribilof Islands Association, supplemented with information from the literature (Chaussonnet, 1995; and Halliday, 1998). Among the Native peoples within the Aleutian Islands ecoregion are the Yup’ik and the Aleut. Many Yup’ik live along the western coast of Alaska, as well as on St. Lawrence and St. Matthews Islands in the Bering Sea. Many Aleut people live on the islands of the Aleutian Archipelago and on the Alaska Peninsula.

52.1.1 Protecting Subsistence Species

Traditional foods of the Yup'ik include walrus, seal, and whale meat and blubber, supplemented by fish, shellfish, and birds.

The Aleuts traditionally harvest whale, fur seals, red salmon, limpets, blue mussels, sea urchins, clams, and seaweed from the sea for subsistence. The Aleuts are also concerned about sea urchins as a food source for sea otters, which are important culturally. Historically, sea lions have been important, because their skins were used to make the traditional Aleut wood-frame boats called iqya'ax. However, harvest of Steller's sea lion is now restricted under the Endangered Species Act. Plant species harvested by Aleuts for subsistence include cow parsnip and fiddlehead ferns.

Foxes may be trapped within the Aleutians for subsistence purposes; this is allowed even within the Maritime National Wildlife Refuge because the foxes are non-native species in the Aleutians.

52.1.2 Protecting Species of Ceremonial Importance

Bearded seals are important to the Yup'ik, who celebrate the first bearded seal caught each season with a seal party, where food, clothing, and toys are shared among community members. The first game caught by a young hunter is also celebrated at this event.

52.1.3 Protecting Commercial Species

Commercial harvesting is a large industry in the eastern portion of the Aleutian Islands ecoregion. Salmon, halibut, cod, and king crab are principal among the species commercially harvested. Many Aleuts make their living as commercial crab, halibut, and cod fishers. Traditional walrus ivory and bone carvings, and clothing made from walrus fur and seal skin, are both a cultural heritage and a source of cash income for the Yup'ik. Trapping of Arctic fox and sea otters may also occur on islands that are outside of areas where it is prohibited. Bird watching draws many tourists to the Aleutians each year. These tourists contribute significantly to the economy of the ecoregion.

52.1.4 Protecting Recreational Species

Recreational fishing is limited primarily to the vicinity of the few inhabited islands. Common freshwater game fish species are Dolly Varden and salmon. A variety of marine fish (halibut and cod) and shellfish species are also caught. Other game species are limited in the Aleutians, but ptarmigan and introduced caribou may be hunted on some islands. Bird watching is a recreational pursuit because of the myriad of sea birds that nest on the Aleutian and Pribilof Islands.

52.1.5 Protecting Regulated Species

A few of the rare, threatened, or endangered (RTE) species found in the Aleutian Islands ecoregion include the Aleutian Canada goose, short-tailed albatross, and Kittlitz's murrelet. Table D.2-1 presents a more complete list and the Latin names of the RTE species for the ecoregion. The U.S. Fish and Wildlife Service (USFWS) manages the Aleutian Islands subunit of the Alaska Maritime National Wildlife Refuge. Protection of sea otters and sea lions, as well as migratory birds, is of special concern to refuge managers.

52.2 Arctic Slope

For the Arctic Slope ecoregion, information on cultural values (Table D.1-2) was obtained from discussions with representatives of the Arctic Slope Native Association and was supplemented with information from the literature (Chaussonnet, 1995; and Halliday, 1998). In the Arctic Slope ecoregion, the predominant Native culture is that of the Inupiat. Native communities in this ecoregion include Barrow, Wainwright, Point Lay, Point Hope, Atqasuk, Nuiqsut, Kaktovik, and Anaktuvuk Pass, which are all located within or north of the Brooks Range.

52.2.1 Protecting Subsistence Species

Traditional foods of the Inupiat include beluga and bowhead whales, walrus, ringed and bearded seals, caribou, moose, musk ox, and several species of fish (including whitefish, Arctic cisco, and grayling). Migratory waterfowl, such as geese and eider ducks, are also used for subsistence. Plant species harvested for subsistence include tundra lichens, blueberries, and salmonberries.

52.2.2 Protecting Species of Ceremonial Importance

The bowhead whale is the center of social and spiritual life for the Inupiat. The catch of the bowhead whale is celebrated throughout the year in several different ceremonies and feasts. Traditional knowledge about whaling and bowhead behavior is passed from generation to generation to sustain the subsistence lifestyle. Whales are sometimes still hunted from umiaks, wooden-frame boats covered in sealskin, that are well suited for moving around the floating blocks of ice common during whaling season.

52.2.3 Protecting Commercial Species

Commercial harvesting of plants, fish, and wildlife is limited within the Arctic Slope ecoregion and generally takes place on a much smaller scale than in the southern portions of Alaska. Wolves, wolverines, and foxes are hunted primarily as a source of fur to provide clothing to family members, but furs are also sold. Byproducts of many of the animals that are hunted for subsistence also sustain a cultural heritage and have some economic value, such as ivory and bone carvings and fur-lined jackets. Some fish species such as salmon or cod are also harvested for commercial sale. Species important for the Alaskan trapping industry include Arctic fox, red fox, otter, lynx, wolves, wolverine, marmot, and weasel. Guided bird watching or wildlife viewing also occurs within the ecoregion.

52.2.4 Protecting Recreational Species

Species important for recreational fishing include trophy sheefish, salmon, whitefish, and Arctic cisco. Wildlife species that draw tourists are polar bears, whales, caribou, and migrating waterfowl and shorebirds.

52.2.5 Protecting Regulated Species

A few of the federal RTE species found in the Arctic Slope ecoregion include the Arctic peregrine falcon, Eskimo curlew, spectacled eider, and Steller's eider. Table D.2-2 presents a more complete list of the RTE species for the ecoregion. The USFWS manages the Arctic National Wildlife Refuge in the northeastern portion of the ecoregion. Protection of the Porcupine caribou herd, muskox, and migratory birds are of special concern to refuge managers.

52.3 Interior

For the Interior ecoregion, information on cultural values (Table D.1-3) was obtained from discussions with representatives of the Tanana Chiefs Conference, supplemented with information from the literature (Chaussonnet, 1995; and Halliday, 1998). In the Interior ecoregion, the predominant Native culture is Athabascan. Forty-four villages and towns are included in this ecoregion, all south of the Brooks Range and north of the Alaska and Wrangell-St. Elias Ranges. Some of these include Tok, Tetlin, Eagle, Paxson, Fairbanks, Delta Junction, Nenana, and Fort Yukon.

52.3.1 Protecting Subsistence Species

Traditional foods of Athabascans include caribou, moose, brown bear, black bear, muskox, and several species of fish (including salmon, whitefish, Arctic grayling, and trout). Migratory waterfowl, such as geese, swan, pintail, teal, and shoveler ducks, are also used for subsistence. Plant species harvested for subsistence include blueberries, salmonberries, cranberries, raspberries, and rhubarb.

52.3.2 Protecting Species of Ceremonial Importance

The raven is a central theme of Athabascan culture and ceremonies. Athabascan ceremonies consist of memorial potlatches that incorporate food, water, fire, song, and dance. Wolves, wolverines, fox, ermine, and marten fur are used in these ceremonies for decoration. Ptarmigan and grouse feathers are also used during these potlatches.

52.3.3 Protecting Commercial Species

The fur trade is especially important to Athabascans. Hats, gloves, and parkas are made from a variety of species, including wolves, wolverines, fox, marten, beaver, mink, muskrat, otter, ermine, hare, coyote, Dall sheep, and lynx. Moccasins are made mainly from the skin of caribou and moose, as well as from the fur of Dall sheep and lynx. Many of these species are also important for the Alaskan fur industry as a whole. The Alaska Trappers Association lists the beaver, Arctic fox, red fox, otter, lynx, marten, mink, muskrat, wolf, wolverine, coyote, marmot, and weasel as valuable species for commercial trapping in this ecoregion. Guided wildlife viewing has also become a valuable commercial business within the ecoregion.

52.3.4 Protecting Recreational Species

Species important for recreational fishing include salmon, whitefish, and Arctic grayling. Wildlife viewing often focuses on caribou and many species of waterfowl.

52.3.5 Protecting Regulated Species

A few of the federal RTE species found in the Interior ecoregion include the Arctic peregrine falcon and Eskimo curlew. These and many other sensitive species in the ecoregion are listed in Table D.2-3. The USFWS manages the Kanuti, Koyukuk, Innoko, Nowitna, Tetlin, and Yukon Flats National Wildlife Refuges within the ecoregion. Much of the area within these refuges provides irreplaceable nesting grounds for waterfowl. However, large and small mammals such as caribou, moose, Dall sheep, bears, wolves, lynx, and foxes, as well as many fish species, including salmon, sheefish, whitefish, grayling and northern pike, are also of concern to refuge managers.

52.4 Northwest

For the Northwest ecoregion, information on cultural values (Table D.1-4) was obtained from discussions with representatives of the Maniilaq Association and was supplemented with information from the literature (Chaussonnet, 1995; and Halliday, 1998). In the Northwest ecoregion, the predominant Native culture is Inupiat. Communities in this ecoregion include Kotzebue, Noatak, Kiana, Ambler, Huslia, Taylor, Teller, and Nome.

52.4.1 Protecting Subsistence Species

Traditional foods of Inupiats include beluga and bowhead whales, walrus, ringed and bearded seals, caribou, moose, muskox, and several species of fish, including whitefish, Arctic cisco, and grayling. Migratory waterfowl, such as geese and eider ducks, are also used for subsistence. Plant species harvested for subsistence include tundra lichens, blueberries, and salmonberries among others.

52.4.2 Protecting Species of Ceremonial Importance

The bowhead whale is the center of social and spiritual life for the Inupiat. The bowhead whale catch is celebrated throughout the year in several different ceremonies and feasts. Traditional knowledge about whaling and bowhead behavior is passed from generation to generation to sustain the subsistence lifestyle. In some cases, whales are still hunted from umiaks, traditional skin boats.

52.4.3 Protecting Commercial Species

Wolves, wolverines, and foxes are hunted as a source of fur to provide clothing to family members, but also for commercial sale. Byproducts of all the animals that are hunted for subsistence, such as ivory and bone carvings and fur-lined jackets, are both a cultural heritage and have some economic value. Some fish species are also harvested for commercial sale. Species important to the Alaska fur industry in this ecoregion include the beaver, Arctic fox, red fox, otter, lynx, marten, mink, muskrat, wolf, wolverine, coyote, marmot, and weasel. Nesting seabirds now draw a large number of tourists to St. Lawrence Island and the coast of the Northwest ecoregion. These tourists contribute significantly to the economy of the region.

52.4.4 Protecting Recreational Species

Species important for recreational fishing include trophy sheefish, salmon, whitefish, and Arctic cisco. Wildlife species that draw tourists are polar bears, whales, caribou, and migrating waterfowl. Bird watching for seabirds is a recreational pursuit on St. Lawrence Island.

52.4.5 Protecting Regulated Species

A few of the federal RTE species found in the Northwest ecoregion include the Arctic peregrine falcon and spectacled eider. Table D.2-4 presents a more complete list of the RTE species for the ecoregion. The USFWS manages the Selawik National Wildlife Refuge in the central portion of the ecoregion. Management for the multitude of migratory water birds is of primary importance to refuge managers. However, caribou, moose, brown bear, and other furbearers, as well as fish such as sheefish, whitefish, grayling, and northern pike, which inhabit the refuge, are also of concern.

52.5 Southcentral

For the Southcentral ecoregion (Table D.1-5), information on cultural values was obtained from the literature (Chaussonnet, 1995; and Halliday, 1998). The predominant Native cultures in this ecoregion are the Athabascan and the Alutiq. Communities in this region include Nabesna, Glenallen, Chitina, Cordova, Valdez, Palmer, Eklutna, Kenai, Homer, Seward, Seldovia, McCarthy, and Anchorage.

52.5.1 Protecting Subsistence Species

Subsistence foods of Athabascans and Alutiqs in this region include caribou, moose, brown bear, black bear, Dall sheep, seals, sea otters, beluga whales, and several species of fish, including salmon, Arctic grayling, and trout. Migratory waterfowl, such as geese, swan, pintail, teal, and shoveler ducks, are also used for subsistence. Plant species harvested for subsistence include blueberries, salmonberries, and rhubarb.

52.5.2 Protecting Species of Ceremonial Importance

The raven is a central theme of the Athabascan culture and ceremonies. Athabascan ceremonies consist of memorial potlatches that incorporate food, water, fire, song, and dance. Wolves, wolverines, fox, ermine, and marten fur are used in these ceremonies for decoration. Ptarmigan and grouse feathers are also used in these potlatches.

52.5.3 Protecting Commercial Species

The fur trade is especially important to Athabascans. Hats, gloves, and parkas are made from a variety of species, including wolves, wolverines, fox, martin, beaver, mink, muskrat, otter, ermine, hare, coyote, Dall sheep, and lynx. Moccasins are made mainly from the skin of caribou and moose, as well as from the fur of Dall sheep and lynx. Alutiqs use sea otter and seal hides for clothing. Salmon, herring, crab, and some other marine species are also harvested commercially within the Gulf of Alaska adjacent to the Southcentral ecoregion. Species important to the Alaska fur industry in this ecoregion include the beaver, red fox, otter, lynx, marten, mink, muskrat, wolf, wolverine, coyote, marmot, red squirrel, and weasel. Ecotourism, sightseeing, and charter hunting and fishing are also important industries that rely on the wildlife and fish of this region, including seabirds, moose, whales and other marine mammals, halibut, and salmon.

52.5.4 Protecting Recreational Species

Species important for recreational fishing include halibut, salmon, trout, and Arctic grayling. Wildlife species important for recreational viewing or hunting include caribou, moose, seals, bears, and many species of waterfowl.

52.5.5 Protecting Regulated Species

Federal RTE species found in the Southcentral ecoregion include the Peale’s peregrine falcon and the Steller sea lion. Table D.2-5 presents a more complete list of the RTE species for the ecoregion. The Kenai National Wildlife Refuge was established to protect the large Kenai moose population, but also provides habitat for many other mammals such as bear, mountain goat, wolf, coyote, fox, lynx, and many small mammals. The refuge also provides irreplaceable fish spawning grounds for many Cook Inlet salmon.

52.6 Southeast

For the Southeast ecoregion (Table D.1-6), information on cultural values was obtained from discussions with representatives of the U.S. Forest Service (USFS) and was supplemented with information from the literature (Chaussonnet, 1995; and Halliday, 1998). In the Southeast ecoregion, the predominant Native cultures are the Tlingit and the Haida. Communities in this region include Metlakatla, Saxman, Ketchikan, Craig, Klawok, Wrangell, Petersburg, Kake, Angoon, Sitka, Hoonah, Juneau, Gustavus, Haines, Skagway, and Yakutat.

52.6.1 Protecting Subsistence Species

Subsistence foods of the Tlingit and Haida include Sitka black-tailed deer, moose, salmon, halibut, cod, herring, crab, mussels, and clams. Migratory waterfowl, such as geese and ducks, are also used for subsistence. Plant species harvested for subsistence include woodland and marsh plants, various berries, and seaweed.

52.6.2 Protecting Species of Ceremonial Importance

The raven is a central theme of Tlingit culture and ceremonies. The image of a raven is often depicted on ceremonial totem poles and other woodcarvings.

52.6.3 Protecting Commercial Species

In the Southeast ecoregion, fish, herring roe, and shellfish are the most important commercial species. Specifically, salmon, halibut, and King and Dungeness crab are among the most important fish or shellfish species harvested for commercial sale. Species important to the Alaska fur industry in this ecoregion include the beaver, red fox, otter, marten, mink, wolf, wolverine, and coyote. Guided bird watching and wildlife viewing area also commercially important.

52.6.4 Protecting Recreational Species

Species important for recreational fishing include salmon and halibut. Marine wildlife species that draw tourists include whales, seals, sea lions, and sea otters. Black bears, brown bears, moose, and waterfowl are recreationally hunted. Crab are also important for recreational purposes.

52.6.5 Protecting Regulated Species

Among the federal RTE species found in the Southeastern ecoregion are Peale’s peregrine falcon and the Steller seal lion. Table D.2-6 presents a more complete list of the RTE species for the ecoregion. The Alaska Maritime National Wildlife Refuge islands within this ecoregion include Forrester Island and St. Lazana Island within Sitka Sound. These islands provide irreplaceable nesting habitat for seabirds and haulouts, as well as rookeries for marine mammals.

52.7 Southwest

For the Southwest ecoregion, information on cultural values (Table D.1-7) was obtained from discussions with representatives of the Aleutian/Pribilof Islands Association and from the literature (Chaussonnet, 1995; and Halliday, 1998). Among Native cultures within the Southwest ecoregion are the Yup'ik, Aleut, and Alutiq. Many Yup'ik live predominantly along the western side of the ecoregion. Many Aleut people live on the Alaska Peninsula, and the Alutiq people are concentrated on and surround Kodiak Island in the eastern portion of the ecoregion. Communities in this ecoregion include Kodiak, Ouzinkie, Port Lions, Larsen Bay, Karluk, Old Harbor, Dillingham, Togiak, Naknek, and Akhiok.

52.7.1 Protecting Subsistence Species

Traditional foods of Yup'iks include walrus, seal, and whale meat and blubber, supplemented by fish, shellfish, and waterfowl. Aleuts traditionally harvest whale, fur seals, red salmon, limpets, blue mussels, sea urchins, clams, and seaweed from the sea for subsistence. Subsistence foods of the Alutiq include Sitka black-tailed deer, elk, salmon, halibut, and seals. Migratory waterfowl, such as geese and ducks, are also used as subsistence food. Plant species harvested for subsistence include cow parsnip and fiddlehead ferns in addition to many of the berries growing within the ecoregion.

The Aleuts are also concerned about sea urchins as a food source for sea otters, which are important culturally, and historically, sea lion skins were used to make the traditional Aleut wood-frame boats called iqya'ax. However, sea lions are now protected from such harvesting.

52.7.2 Protecting Species of Ceremonial Importance

Bearded seals are important to the Yup'ik, who celebrate the first bearded seal caught each season with a seal party, where food, clothing, and toys are shared among community members. The first game caught by a young hunter is also celebrated at this event. The walrus is an important symbol for the Alutiq people. Walrus whiskers are used to decorate traditional wooden hunting visors.

52.7.3 Protecting Commercial Species

In the Southwest ecoregion, commercial harvesting is a large industry. Salmon, halibut, cod, herring, and King crab are among the most important fish and shellfish species that are harvested for commercial sale. One of the largest salmon runs in the world is located in Bristol Bay. Seal hides are also used in clothing. Traditional walrus ivory and bone carvings, and clothing made from walrus fur and seal skin, are both a cultural heritage and a source of cash income for the Yup'ik. Trapping of fox, sea otters, and other furbearers may also occur in some areas. Species important to the Alaska fur industry in this ecoregion include the beaver, Arctic fox, red fox, otter, lynx, marten, mink, muskrat, wolf, wolverine, marmot, red squirrel, and weasel. Guided hunts for caribou and moose, and fishing trips for salmon and trout are important commercial endeavors in the ecoregion.

52.7.4 Protecting Recreational Species

Species important for recreational wildlife viewing include the Kodiak brown bear, sea lions, seals, whales, puffins, and kittiwakes. Species important for recreational fishing include salmon and halibut. Common freshwater game fish species are rainbow trout, Dolly Varden, and salmon. A variety of other marine fish (e.g., cod) and shellfish species are also caught. Other game species, including ptarmigan, waterfowl, caribou, elk, and deer, may also be hunted.

52.7.5 Protecting Regulated Species

Among the federal RTE species found in the Southwestern ecoregion are the Arctic peregrine falcon and the Steller seal lion. Table D.2-7 presents a more complete list of the RTE species for the ecoregion. The Alaska Peninsula, Becharof, Izembek, Kodiak, and Togiak National Wildlife Refuges are found within this ecoregion. These refuges are managed for a multitude of large and small mammals, marine mammals, birds, and fish. Some of these include brown bear, moose, caribou, sea lions, harbor seals, otters, ducks, geese, seabirds, shorebirds, hawks, songbirds, salmon, and trout. The diversity of these refuges is very high compared with the more northern refuges, in part because of their milder maritime-influenced climates.

52.8 Yukon-Kuskokwim Delta

For the Yukon-Kuskokwim Delta ecoregion, information on cultural values (Table D.1-8) was obtained from the literature (Chaussonnet, 1995; and Halliday, 1998). In the Yukon-Kuskokwim Delta ecoregion, the predominant Native cultures are Yup'ik and Athabascan. Fifty-six Yup'ik villages are located in the Yukon and Kuskokwim River Delta, including Aniak, Bethel, Quinhagak, and Nunivak Island.

52.8.1 Protecting Subsistence Species

Traditional foods of the Yup'ik include walrus, seal, and whale meat and blubber, supplemented by fish, shellfish, and birds. Muskox and reindeer are also part of their diet. Plant species harvested for subsistence include cranberries, salmonberries, and rhubarb.

Subsistence foods of the Athabascans include caribou, moose, brown bear, black bear, muskox, sheep, and several species of fish, including salmon, Arctic grayling, and trout. Migratory waterfowl, such as geese, swan, pintail, teal, and shoveler ducks, are also used for subsistence. Plant species harvested for subsistence include blueberries, salmonberries, and rhubarb.

52.8.2 Protecting Species of Ceremonial Importance

Bearded seals are important to the Yup'ik, who celebrate the first bearded seal caught each season with a seal party, where food, clothing, and toys are shared among community members. The first game caught by a young hunter is also celebrated at this event.

The raven is a central theme of Athabascan culture and ceremonies. Athabascan ceremonies consist of memorial potlatches that incorporate food, water, fire, song, and dance. Wolves, wolverines, fox, ermine, and marten fur are used in these ceremonies for decoration. Ptarmigan and grouse feathers are also used in these potlatches.

52.8.3 Protecting Commercial Species

Traditional walrus ivory and bone carvings, and clothing made from walrus fur and seal skin, are both a cultural heritage and a source of cash income for the Yup'ik. Salmon fishing and harvesting of King crab also brings in income.

The fur trade is especially important to the Athabascan. Hats, gloves, and parkas are made from a variety of species, including wolves, wolverines, fox, marten, beaver, mink, muskrat, otter, ermine, rabbit, coyote, sheep, and lynx. Moccasins are made mainly from the skin of caribou and moose, as well as from the fur of Dall sheep and lynx. Many of these species are also important for the Alaskan fur industry as a whole. The Alaska Trappers Association lists the beaver, Arctic fox, red fox, otter, lynx, marten, mink, muskrat, wolf, wolverine, marmot, red squirrel, and weasel as valuable species for commercial trapping in this ecoregion. Guided sea bird viewing trips are also becoming more common in this ecoregion.

52.8.4 Protecting Recreational Species

Species important for recreational fishing include salmon, trout, and Arctic grayling. Wildlife species important for recreational viewing include walrus, seals, sea lions, caribou, bears, and many species of waterfowl. In addition, bird watching has become a recreational attraction at St. Mathew Island because of its seabirds.

D.2.8.5 Protecting Regulated Species

RTE species for the ecoregion are presented in Table D.2-8. The Yukon Delta National Wildlife Refuge is found within this ecoregion. This refuge encompasses a large, treeless wetland that provides irreplaceable habitat for millions of waterfowl and shorebirds. Moose, caribou, bears, and wolves are also important aspects of the refuge fauna. The muskox on Nunivak Island have been prolific breeders and used to transplant the once-abundant muskox to other areas of Alaska within its historic range. Fish are also abundant in the thousands of lakes, ponds, and streams and provide food for Alaska Natives as well as for wildlife.

53REGIONAL ECOLOGY AND FUNCTIONAL GROUPING

Species lists for each ecoregion were developed and then divided into functional groups based the following steps:

- List species inhabiting the ecoregion.
- Classify by species type.
- Classify by primary foraging strategy.
- Classify based on foraging habitat qualifier.
- Sort by classification into functional groups.

These steps are discussed in more detail in the following subsections. The resulting functional groups are presented by ecoregion in Tables D.3-1 through D.3-8.

53.1 Listing of Species in the Ecoregion

Species lists for each ecoregion were developed by compiling information from a variety of available resources on the ecology of Alaska. The lists are reasonably complete but are unlikely to contain every species that inhabits each ecoregion. The common and scientific or Latin names of species likely to be found in each ecoregion are provided in columns 1 and 2, respectively, of Tables D.3-1 through D.3-8.

53.2 Classification by Species Type

Each species was classified into one of the following categories: amphibians, birds, fish, invertebrates, mammals, or vegetation. Reptiles were not included because none inhabit Alaska. The species types for each species within each ecoregion are provided in column 3 of Tables D.3-1 through D.3-8.

53.3 Classification by Primary Foraging Strategy

Species were categorized by their primary foraging strategy. This approach was taken because of the association between the primary foraging strategy and food chain modeling methodologies that are common within ERAs at hazardous waste sites.

Assigning a primary foraging strategy included consideration of two components: the primary type of habitat from which prey/food items/nutrients are obtained and the trophic level of the species.

The primary habitats of prey/food items were defined as aquatic, epiphytic, semiaquatic/benthic, or terrestrial:

- **Aquatic.** A species was considered aquatic if it obtains its nutrients or sustenance primarily from the water column or from prey that obtain sustenance primarily from the water column, with no affiliation to soil or sediment.

- **Epiphytic.** A species was considered epiphytic if it obtains nutrients or sustenance primarily from the air and/or rainwater.

- **Semi-aquatic.** A species was considered semi-aquatic (or benthic for invertebrates) if it obtains all or a portion of its nutrients or sustenance from sediment (including interstitial sediment pore water) or from prey that obtain sustenance primarily from sediment or sediment pore water.

- **Terrestrial.** A species was considered terrestrial if it obtains nutrients or sustenance primarily from soil (or interstitial soil pore water) or from prey that obtains sustenance primarily from nutrients in soil or soil pore water.

For example, a herbivore feeding on planktonic species would be classified as aquatic because plankton derive sustenance from sunlight and nutrients in the water column. On the other hand, a herbivore feeding on eelgrass would be classified as semi-aquatic because the eelgrass derives its sustenance from the sediment, not the water column. A herbivore feeding on berries would be classified as terrestrial because the berry bush derives its sustenance from the soil. Lichens and some mosses that obtain their nutrients from the air are categorized as epiphytic. Trophic-level categories include:

- Vegetation (primary producer)
- Herbivore (primary consumer)
- Detritivore (primary consumer)
- Invertevore (secondary consumer)
- Carnivore (tertiary consumer)

Trophic level was determined by examining the primary prey items, food, or source of nutrients for a species as described by Ehrlich et al. (1988). These primary sources of nutrients were determined as those that are consumed for a majority of the time that the species spends in an ecoregion and/or that provide a majority of the sustenance for a species while it resides in Alaska.

In many cases, a species will change its foraging habits depending on season and food/prey availability. This was accounted for by providing a secondary foraging strategy for each species listed in Tables D.3-1 through D.3-8. This secondary foraging strategy may be used on a site-specific basis to allow consideration of an alternate functional grouping of a species, where appropriate. For example, if a robin (primarily a terrestrial avian invertevore) that inhabits a site forages primarily on berries at the site, adjustment could be made by assigning the robin to a functional group associated with its secondary foraging strategy (e.g., terrestrial avian herbivore).

The combinations of foraging habitat type and trophic level were used to determine a species' primary and secondary foraging strategies. The primary foraging strategies were, in turn, used as one factor in assigning species to functional groups. The secondary foraging strategy was not used in the classification and sorting of default assessment endpoints or primary indicator species. Each species was categorized into one of the following foraging strategies and assigned a corresponding alphanumeric designation:

- **A0 Aquatic Vegetation**. A primary producer with its nutrients obtained from the water column. Some aquatic vegetation in this category is sometimes anchored to the substrate via a holdfast (e.g., kelp), but derives its nutrients from the water column, not via a vascular root system that accesses nutrients in the sediment.

- **A1 Aquatic Herbivore.** A primary consumer species that relies on aquatic vegetation.

- **A2 Aquatic Detritivore.** A primary consumer species that relies on decaying plant and animal matter in the water column or resting on the bottom substrate of a water body.

- **A3 Aquatic Invertevore.** A secondary consumer that relies on aquatic invertebrates such as snails, limpets, or mayflies that are attached to or associated with the bottom substrate. This includes species that glean invertebrates from the bottom but do not probe into the sediment.

- **A4 Aquatic Carnivore.** A predator that primarily consumes aquatic vertebrates (aquatic vertebrates rely primarily on the aquatic food web [within the water column]). Fish, seals, and seabirds are examples of aquatic vertebrate species.

- **S0 Semi-aquatic Vegetation.** A primary producer that possesses a definite vascular root system and derives most of its nutrients from the sediment or sediment interstitial pore water.

- **S1 Semi-aquatic/Benthic Herbivore.** A primary consumer species that relies on semi-aquatic vegetation.

- **S2 Semi-aquatic/Benthic Detritivore.** A primary consumer that relies on decaying plant and animal matter.

- **S3 Semi-aquatic/Benthic Invertevore.** A secondary consumer that relies on sediment-dwelling invertebrates. This primarily includes probing species that remove invertebrates from within sediment. It does not include species that glean aquatic invertebrates from the surface of the bottom substrate.

- **T0 Terrestrial Vegetation**. A primary producer that possesses a definite vascular root system and derives most of its nutrients from the soil or soil interstitial pore water.
- **T1 Terrestrial Herbivore.** A primary consumer that relies on terrestrial vegetation.
- **T2 Terrestrial Detritivore.** A primary consumer that relies on decaying terrestrial plant or animal matter.
- **T3 Terrestrial Invertevore.** A secondary consumer that relies on terrestrial invertebrates.
- **T4 Terrestrial Carnivore.** A predator that primarily consumes terrestrial vertebrates.
- **E0 Epiphytic Vegetation.** A primary producer that derives its nutrients from the air.

The primary and secondary foraging strategies are provided for each species within an ecoregion in columns 4 and 5, respectively, in Tables D.3-1 through D.3-8.

Fish-eating species (piscivores) were differentiated from other carnivores because piscivores are frequently selected as indicator species within ERAs and considered independently from other carnivores. Piscivores are assessed to define the risks to higher trophic-level species as a result of contamination in aquatic habitats. When fish consumption was a dietary preference for a particular species, a large “X” was placed in column 6 of Tables D.3-1 through D.3-8. This piscivore designation was used in determining the appropriate functional group for that species. A small “x” indicates a species that eats fish opportunistically but not as its primary source of nutrients and was not used in the classification process.

53.4 Classification by Foraging Habitat Qualifier

The primary foraging strategy for each species was further defined through assignment of a foraging habitat qualifier. A large X in the habitat qualifier columns designates which habitats(s) is/are dominant for a given species. For many species, this varies from location to location; in such cases, two or more large X’s were used to denote each of the likely foraging habitats for a species and to categorize species into functional groups. A small x is used if the habitat is not dominant, but may play an important role for a particular species during various times of the year or for a particular period in a species’ life cycle. The small x was not used in defining functional groups.

Species were defined as marine, estuarine, freshwater, soil-associated, and/or sediment-associated. More than one designation may apply to a given species. Aquatic species were defined as either marine or freshwater, using a large X. Semiaquatic/benthic species were defined as sediment-associated by placing an X in the sediment column; in addition, they were designated as marine or freshwater. In some cases, they were also designated as soil-associated. For both aquatic and semiaquatic/benthic species, estuarine was included as a descriptive classification, but was not used for determining functional groups because estuarine habitat use was always associated with a marine or freshwater preference. Terrestrial species were always designated as soil-associated. The habitat qualifiers are presented for each species within an ecoregion in columns 7 through 11 of Tables D.3-1 through D.3-8. The criteria applied to assign these qualifiers follow.

Marine	Definition:	Forages in the marine environment.
	Example:	Seabirds foraging on fish, or species that forage primarily on such seabirds.
Estuarine	Definition:	Forages in transitional (brackish) areas between marine and freshwater environments.
	Example:	Shorebirds foraging on river deltas.
Freshwater	Definition:	Forages on aquatic species in freshwater environments supported by groundwater, rivers/streams, or precipitation.
	Example:	Kingfisher feeding on fish from a lake or stream.
Sediment	Definition:	Forages in or grows from a substrate that is generally under water (seasonally or permanently). This modifier is used to describe foraging from the sediment or on sediment-rooted plants in marine, estuarine, or fresh water bodies/wetlands.
	Examples:	Plants that are rooted in sediment. Mallard that eats vegetation or invertebrates that obtain their sustenance from sediment or sediment pore water.
Soil	Definition:	Forages in or grows from a soil substrate that is generally not under water. This modifier is used to describe foraging from the soil, on soil-dependent species, or on soil-rooted plants.
	Examples:	Terrestrial plants. American robin eating earthworms.

53.5 Definition of Functional Groups

Based on the results of the proceeding steps, species were sorted by type, within type by primary foraging strategy with further distinction between carnivores and piscivores, and within primary foraging strategy by habitat qualifier in the order: marine, estuarine, fresh, sediment, soil. The unique combinations of type, foraging strategy, and foraging habitat qualifier (except estuarine as discussed above) comprised the functional groups. Small "x's" were not used in the sorting process and are provided solely for the purpose of highlighting additional exposure routes that may need to be considered for a species under some site conditions. Finally, each species within a functional group was sorted by size. Size was determined as large, medium, or small, in relation to species within the same taxonomic class. Size was not used to determine functional groups, but aided in the selection of default primary indicator species as discussed in Section D.4 below. Sorting by size was not conducted for amphibians, fish, invertebrates, or plants because these species are not warm blooded, and thus, their metabolism and associated dietary/sustenance needs (i.e., exposures) are not affected by their size.

Common and scientific-species names, species types, primary and secondary foraging strategies, status as piscivores, habitat qualifiers, size, and functional group categories are shown for each ecoregion in Tables D.3-1 through D.3-8.

53.6 Ecoregion-specific Considerations

There were a few instances in which the results of the functional grouping were unexpected or may not be representative of an entire ecoregion. Within the Aleutian Islands ecoregion, the fox was classified as an aquatic carnivore because it feeds primarily on seabirds, their eggs, and their young. Since these seabirds are aquatic foragers, the fox is an aquatic carnivore. This concept may also be true for some of the other coastal areas of Alaska, but in other Alaskan ecoregions the fox was always classified as a terrestrial carnivore.

The Arctic Slope ecoregion could have been divided into western and eastern regions, because many species are found only within the westernmost portions of the ecoregion and not in the central or eastern portions. This is the case because of the severity of the winters and the increased distance from ice-free waters. Since functional groups were developed for the entire Arctic Slope, it is likely that many of the default functional groups can be removed from consideration on a site-specific basis for ERAs in the eastern portion of the Arctic Slope, because there are no representatives of the group present. A mechanism has been provided to allow for such elimination of functional groups during site-specific selection of appropriate functional groups, assessment endpoints, and indicator species (See Section 5.0 of the Technical Background Document).

54DEFINING ASSESSMENT ENDPOINTS AND INDICATOR SPECIES

Assessment endpoints were selected to ensure protection of ecosystem health by considering each defined functional group. Indicator species were then selected to represent each assessment endpoint that could be assessed within an ERA.

54.1 Assessment Endpoints

In order to ensure protection of ecosystem health (an overall societal value), it is necessary to protect each functional group represented and potentially exposed at a particular site. By protecting each functional group, it is assumed that specific ecological resources particularly valued by society will also be protected. Therefore, default assessment endpoints were determined for each functional group. Tables D.4-1 through D.4-8 present the assessment endpoints and the relationship between biological function and societal value for each of the functional groups defined in Section D.3 and Tables D.3-1 through D.3-8, based on the societal values defined in Section D.2 and in Tables D.1-1 through D.1-8 and D.2-1 through D.2-8. Most assessment endpoints apply in each ecoregion because most functional groups are represented in each ecoregion. However, some assessment endpoints do not apply to a particular ecoregion because a given functional group is not represented. For example, the marine assessment endpoints do not apply in the Interior ecoregion. Table D.4-9 summarizes the default assessment endpoints, indicating the ecoregions to which they apply.

In some cases, multiple functional groups were combined and represented by a single assessment endpoint to support current Tier I ERA methodologies:

- Herbivores and detritivores with similar primary habitat types and habitat qualifiers.
- The functional groups classified as both marine and freshwater ("marine/freshwater" in Tables D.3-1 through D.3-8) were not each provided separate assessment endpoints. This was done because at a vast majority of sites the receptors only will be exposed to marine or fresh water, but not both. In addition, it was assumed that separate "Marine" or "Freshwater" assessment endpoints would adequately address exposure of the marine/freshwater species. This should be the case for vast majority of contaminated sites in Alaska. If a species is exposed to site-related contaminants in both fresh water and marine water (but a similar species is not exposed exclusively to fresh water or marine water), site-specific conditions should be used to select an appropriate marine/freshwater assessment endpoint. If selection of a "marine/freshwater" indicator species becomes necessary, possible indicator species for these functional groups are indicated in bold in Tables D.3-1 through D.3-8.

These approaches allow for simplification in light of current Tier I ERA methodology. Tier II or Tier III ERAs may require separation of these combined functional groups on a site-specific basis. Therefore, some possible indicator species within each defined functional group (except for vegetation) are noted in bold within Tables D.3-1 through D.3-8 for potential use within Tier II or Tier III ERAs.

54.2 Indicator Species

Once assessment endpoints were defined, associated default primary indicator species were selected. The qualitative selection process was based primarily on determining a species within each functional group that was likely to have the highest potential for exposure to chemicals at any given contaminated site. Primary factors related to exposure potential that were considered included:

- Body size and home range
- High-density population
- Foraging approach of the species
- Ecological niche(s) represented by a species

Other factors that influenced the selection of some default primary indicator species included:

- Widespread occurrence
- Availability of exposure and toxicity data
- Societal value of the species (Section D.2)
- Regulatory status of species (Section D.2)

The use of these factors in the selection of default primary indicator species is discussed in the subsections below.

In many cases during the selection of default primary indicator species consideration was given to currently applied ERA methodologies. Specifically, many of the functional groups that are composed of lower trophic-level species are frequently assessed as groups rather than by using indicator species. These functional groups include:

- Freshwater plants
- Marine plants
- Freshwater semi-aquatic plants
- Marine semi-aquatic plants
- Terrestrial plants
- Epiphytic plants

< Freshwater invertebrate herbivores and detritivores
< Marine invertebrate herbivores and detritivores
< Freshwater benthic invertebrates
< Marine benthic invertebrates
< Terrestrial invertebrates
< All freshwater fish functional groups
< All marine fish functional groups

Because the current Tier I ERA methods do not generally involve individual assessment of specific species within these functional groups, default indicator species were not selected for them for use in Tier I ERAs. Rather, species within these functional groups are to be assessed collectively (See Table D.4-9). In fact, in some cases even multiple assessment endpoints can be assessed with a single method in a Tier 1 ERA (e.g., protection of aquatic plants, invertebrates, and fish).

Even though default indicator species were not defined for every functional group in Tables D.4-1 through D.4-8 for Tier I ERAs, possible indicator species for these functional groups (except vegetation) are indicated in bold on Tables D.3-1 through D.3-8 to aid in the selection of potential indicator species to be used in Tier II and Tier III ERAs. The most appropriate indicator species for these functional groups should be determined after careful examination of the site-specific aquatic conditions, including water quality parameters and character of the media of concern. Possible indicator species for terrestrial plants for use in Tier II/III ERAs were not selected because the species present at each site vary greatly, and it is unknown whether a particular wild species is adequately representative of other species. Indicator species for aquatic and semi-aquatic plants were not provided because they are not commonly evaluated in Tier 2 or Tier 3 ERAs.

54.2.1 Body Size and Home Range (Primary Controlling Factor in Exposure Potential)

The exposure potential of indicator species is important because it is a determining factor in the potential for effects, with higher exposure generally related to more serious effects (up to a threshold effect level or death, whichever is realized first). Body size is an important measure of potential exposure because it is inversely correlated with metabolic rate for mammals, birds, and reptiles (Nagy, 1987). In general, a higher metabolic rate indicates the need for a higher foraging rate per body weight. Thus, smaller species are likely to receive a higher dose of ingested site-related contaminants. Smaller species generally have more limited home ranges as well, so they are more likely than larger species to forage entirely within the confines of particular contaminated sites. Therefore, small body size was the most important factor in choosing the default primary indicator species (listed in Tables D.4-1 through D.4-8) for a particular functional group.

54.2.2 High Density, Foraging Approach, and Niche.

When several species within a functional group had similar body size, several other exposure-related factors were examined. These included population density, foraging approach, and niche. Population density is important because a species must be present at a density that provides adequate exposure potential to multiple individuals. This allows for consideration of the potential for population-level effects. Foraging approach is an important factor in determining exposure because it determines from which media a species gets its food and the extent to which it may be exposed. For example, if one terrestrial invertevore picks invertebrates from the soil surface while another probes or digs for shallow subsurface invertebrates, the species that probes or digs has a higher exposure potential because it is likely to ingest a higher proportion of contaminated soil than the species that picks invertebrates from the surface or air. In addition, the prey invertebrates ingested by the probing species are in greater contact with the contaminated soil and thus are more likely to contain significant concentrations of the contaminants of potential ecological concern. Ecological niche is closely related to the foraging approach; however, it is possible that species have similar foraging approaches and different niches. For example, winter wrens and Lapland longspurs are both terrestrial avian invertevores that glean invertebrates from the surface of grass and soil. However, in the Aleutian Islands, the winter wren inhabits rocky or sandy beach bluffs, while the Lapland longspur inhabits wet and dry meadow habitats. Therefore, the longspur is more likely to be exposed and was chosen as the default primary indicator species because contamination is more likely to remain in the organic soils, water, and sediment associated with upland meadows than it is in rocky or sandy beaches.

54.2.3 Additional Selection Criteria

Although exposure potential was used as the primary selection criterion for default indicator species, other secondary factors also were considered. These included widespread occurrence, availability of exposure and toxicity data, societal value of the species (Section D.2), and regulatory status of the species (Section D.2).

Widespread occurrence is particularly important in ensuring that the defaults are appropriate for the majority of sites within an ecoregion. By using the same indicator species at many sites, the level of effort required to defend the selection of indicator species is decreased, and the comparability of results between contaminated sites is higher. Ideally, the default primary indicator species would be both common within a region and likely to be present in relatively high densities at most sites within the region. Because of this selection criteria, rare, threatened, or endangered species were not selected as default primary indicator species. Consideration of such uncommon species as indicator species is a site-specific decision and is described in Section 5.4 of the Technical Background Document.

Availability of exposure and toxicity data is a criterion that is based on professional judgement and ERA knowledge. For some species such as mice and rats, a large amount of exposure and toxicological data are available. This is also true for some other frequently tested species such as quail and mallards. Data for other species can often be extrapolated from the available data. In general, toxicological benchmarks for aquatic invertebrates and fish (ambient water quality criteria), benthic invertebrates (toxicity benchmarks), and mammals (laboratory toxicity data) are better represented in the toxicological literature than are other species. This availability of exposure and toxicity data played a role in the selection of some default primary indicator species.

The general societal goal of protecting ecosystem health is a primary basis of our functional grouping approach. Overall, to be protective of an entire functional group, it was necessary to select default primary indicator species that were likely to be the most highly exposed species within the functional group they represent. Generally, this resulted in selection of the smallest species in a functional group. Many other societal values (including subsistence, ceremonial, commercial, recreational, and regulated species) are associated with particular species. Because these species are typically larger animals, most often they were not selected as default primary indicator species. However, protection of the more exposed default primary indicator species generally will also ensure protection of the larger, more culturally valued species within the same functional group. When there were several species of similar small size, then selection of the default primary indicator species relied mostly on consideration of other parameters that influence exposure. When all other factors were similar or equal, the societal value of a species did influence selection of defaults. Therefore, a species of particular societal value was generally chosen as a default primary indicator species only when it was also among the most highly exposed species. To do otherwise would be underprotective of other more exposed species within a functional group.

The final list of default assessment endpoints and default primary indicator species is summarized in Table D.4-9. These defaults provide a starting point for ecological risk assessors as they determine what is to be assessed at a given site. The listed functional groups and species provide a guide for what to verify during site visits and project scoping, and during development of the Preliminary Problem Formulation. As more site-specific information is gathered, the defaults may be modified as presented in Section 5.0 of the Technical Background Document.

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