FINAL REPORT

A SCOPING ANALYSIS TO ASSESS THE EFFECTS OF ROADS IN ALASKA ON HABITAT QUALITY AND CONNECTIVITY

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A REPORT TO THE ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES

PREPARED BY THE ENVIRONMENT AND NATURAL RESOURCES INSTITUTE, UNIVERSITY OF ALASKA ANCHORAGE

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PROJECT SUMMARY

The purpose of this project was to build a "toolbox" of information that may be used by the Alaska Department of Transportation & Public Facilities (ADOT&PF) to assess the effects of existing and proposed roads on habitat quality and connectivity. As a subtext, the project focused on the ability of Geographic Information Systems (GIS) to assist transportation planners with project development.

To achieve this purpose, the toolbox needed to contain several important pieces of information including:

1. Whether Alaskans are concerned about the effects of roads on habitat quality and connectivity;
2. Who is concerned and for what reasons;
3. About what species and areas people are concerned;
4. What direct and indirect effects roads and their related infrastructure have on habitat quality and connectivity for species and areas of interest;
5. Literature, especially literature pertinent to Alaska, related to the effects of roads on habitat quality and connectivity; and
6. GIS data and methods that can be used by planners to inform the road design process by promoting designs that minimize the negative effects of roads on species and areas of concern.

We collected this information over the course of approximately five months through individual research and by holding two workshops. Workshop participants played a key role in informing our research and contributing information based on their areas of expertise.

Results of this project include the creation of a list of persons concerned about the effects of roads on habitat quality and connectivity, a database of relevant literature, GIS data sets and methods useful for project development, and summaries from two workshops.

Additionally, we developed a list of recommendations stemming from the workshops. Workshop participants suggest that ADOT&PF should:

(1) Organize all data about existing and proposed roads in GIS databases. Analysis of these data sets should focus on:
    a. Assessment of direct and indirect impacts of roads on species of concern,
    b. Effectiveness of restoration demonstration projects, and
    c. Changes in ecological processes that occur as a result of roads and their related activities;

(2) Employ the literature identified in this project to better inform future decision-making with regard to:
    a. Road design and placement
    b. Potential effects to species of concern, including species of commercial, wildlife viewing, hunting, fishing, and other values;

(3) Prepare a "manual" to assist transportation planners with road design and project development;

(4) Contact interested parties when planning future projects; and

(5) Develop a database of local and traditional knowledge. Because this information is not often published, it is important information absent from this study.

Additionally, because it is important to provide access to the information we collected during this study, we have created a project website (http://www.akhcp.org). The website contains a project summary and miscellaneous project documents, workshop summaries, project-team contact information, and most importantly searchable databases containing persons who have identified themselves as being interested in this issue, relevant literature, and GIS data sets.

The result of this project is that transportation planners now have access to a suite of information that will enable them to better plan and design road projects. Our hope is that up-front use of this information will streamline the road design process *and* minimize the negative effects of roads on habitat quality and connectivity.

1.0 INTRODUCTION

1.1 Background

In late 1992, the Federal Highway Administration (FHWA), Alaska Division and the Alaska Department of Transportation and Public Facilities (ADOT&PF) requested and received funding from FHWA, HQ to evaluate habitat connectivity in Alaska. The primary purpose of the study was to answer the questions:

1. Do we need to be concerned about the effects of the Alaska transportation system on habitat connectivity?
2. What areas of the state are the potential for impacts from habitat connectivity of greatest concern?
3. What species are at great risk from reduced habitat connectivity?
4. What GIS data is available in Alaska to assist ADOT&PF planners and engineers?

Habitat fragmentation caused by highway development is a serious concern throughout the U.S., and the world. Since the mid-1990s, state and federal transportation officials and land and wildlife management agencies have been looking for ways to address this problem, which occurs when a highway alters habitat and impedes movement in the landscape.

Many important movement corridors for species including elk (*Cervus elaphus*), wolves (*Canis lupis*) and bears (*Ursus spp.*) in the Northern Rockies and western Canada coincide with major transportation facilities, such as the I-90 corridor and the Trans-Canadian Highway (Clevenger et al. 2002, Gibeau and Herrero 1998, Callaghan et al. 1999). To complicate matters, highways and railroads often share the same corridors.

Alaska's highways, which are few in comparison to the Lower 48, are mostly two-lane. Narrow, two-lane highways with low traffic volumes generally place limited restrictions on the movement of large mammals. However, as traffic increases, these two-lane highways are being upgraded to add wider shoulders, passing lanes, and additional driving lanes. In addition, though the annual traffic volume in Alaska is low on most public highways, the volume between June and September can be extreme. This summer peak can cause serious harm to wildlife by stymieing movement.

1.2 Purpose

Is habitat connectivity an issue in Alaska, and if so, for whom and for what species at what locations? Additionally, if this is an issue, what can we do about it? How can transportation planners better address the potential negative effects of roads on habitat quality and connectivity through the road design process? What tools can the ADOT&PF acquire that will help address this issue? For example, who in the state is interested in this issue and why, about what species do we need to be concerned, in what areas of the state should we be concerned, what literature is available to help address this issue, and what GIS data sets and methods are available that could assist in addressing these concerns?

The purpose of the Habitat Connectivity Project was to answer the above questions by creating a toolbox of information that will enable the ADOT&PF to assess the effects of existing and proposed roads on habitat quality and connectivity. This report serves as a summary of key pieces of information that will facilitate more time and cost-efficient project development by promoting more sensitive road design that minimizes the negative effects of roads on species and areas of concern.

1.3 What is meant by habitat quality and connectivity?

Habitat is defined as an area in which a plant or animal lives (Begon et al. 1996). More specifically, habitat is an area that possesses the resources necessary for an organism or population of organisms to carry out all or a portion of its life cycle (Meffe and Carrol 1997). Resources include food, cover, flows of energy and nutrients, and other biotic and abiotic characteristics that comprise a healthy ecological system (Begon et al 1996, Chiras et al. 2002). Habitat is species specific (Begon et al. 1996). That is, an area can serve as habitat to many species; however each species may require unique combinations and specific amounts of resources to find an area suitable. If necessary resources do not exist, or do not exist in proper amounts, an area may become unsuitable – that is, cease to be habitat. Individuals may move in the attempt to find a suitable area or they may die.

Additionally, habitat can vary in extent. In some places, habitat exists in large, unbroken tracts of land, where species can move and acquire resources. However, habitat is often distributed in a mosaic of patches across a landscape (Turner et al. 2001). In this case, species must be able to cross areas of non-habitat to meet their needs. A classic example of this includes species that migrate between summer and winter habitat and must swim upstream or otherwise move to specific habitat to breed.

The ability to move within a landscape and access habitat is important for the persistence of many species. This requires scientists to gain a detailed knowledge of the landscape and species of interest.

Habitat connectivity is a term that also relates to landscape suitability. Connectivity suggests the degree to which landscape characteristics facilitate or impede the ability of an organism to move within a landscape and acquire resources (e.g., food, cover, nutrients, Fahrig and Merriam 1985). Because habitat contains required resources for a species, it is likely the "easiest" to move through. However, if habitat for a species is distributed in patches across a landscape, individuals may find it difficult or impossible to access required resources (Debinski and Holt 2000).

For example, it may be trivial for a raven (*Corvus corax*) to access patches of habitat distributed across a landscape. On the other hand, it may be impossible for a northern bog lemming (*Synaptomys borealis*) to do so, depending on the size and nature of the intervening area of non-habitat. Therefore, habitat connectivity is both species and landscape specific, and depends on the scale at which species of interest interact with their environment.

The converse of habitat connectivity is habitat fragmentation, or the breaking-up of habitat into smaller, disconnected patches (Turner et al. 2001). Although natural fragmentation exists in

Alaska (e.g., fragmentation due streams, ice fields, mountain ranges), anthropogenic, or human-caused, fragmentation also exists. For the purposes of this project, we are concerned with the effects of roads on habitat quality and connectivity.

1.4 What are the effects of roads on habitat quality and connectivity?

The extent to which habitat fragmentation affects species depends on the characteristics of the species (e.g., size, locomotion, and gap crossing tolerances) and intervening area (e.g., the nature and size of the area of non-habitat, Harrison 1992). As mentioned above, species require different resources and have different abilities to negotiate a landscape. As a result, roads have differing effects. For example, salmon (*Oncorhynchus spp*.) require specific substrates in which to lay eggs, and streams with high levels of dissolved oxygen, cool temperatures, and that are relatively unobstructed (Beauchamp 1983). Areas of forest cleared for road construction, roads with improperly constructed culverts or from which fine sediments enter the stream and alter streambed structure may negatively affect habitat quality and connectivity (Inoue and Nakano 1998). Alternatively, moose (*Alces alces*) are likely unaffected by culverts or siltation. Rather, moose may be negatively affected by bridges that cross riparian areas (Pierce and Peek 1984). As a result, individuals may cross roads with potential negative effects to both moose and motorists.

Research in the lower-48 suggests that grizzly (brown) bears (*Ursus arctos*) are negatively affected by habitat fragmentation induced by roads. Avoidance of high quality habitat near roads or development may decrease the overall health of bears and cause an increase in mortality (Gibeau et al. 2002). Additionally, grizzly bears in the Rocky Mountains showed a significant reduction in use of areas within 100 m of forest roads and showed a quantifiable reduction in use of areas within 250 m of the same roads. These results are independent of traffic volume, indicating that even logging roads with little traffic can have a negative effect on bears (McLellan and Shackleton 1988). During a 25-year study of brown bears in southern Norway, researchers recorded a significant reduction in bear observations with increased road density (Elgmork 1978). Furthermore, in a study conducted in Denali National Park, brown bear densities were higher in the backcountry than within 600 m of the road (Yost and Wright 2001).

Roads may also have negative effects on caribou (*Rangifer tarandus granti*). Although research regarding the effects of roads on barren-ground caribou is limited, several key studies have been published suggesting that roads displace caribou from their preferred habitat (Burson et al. 2000, Curatolo and Murphy 1986, Nellemann et al. 2003, Smith et al. 1994). Inverse relationships have been reported between caribou and road density in the Kuparuk area of Prudhoe Bay, Alaska, with adult females and calves being more susceptible to road displacement than adult males and yearlings (Nellemann and Cameron 1998). Furthermore, mild displacement effects have been observed near the Denali Highway (Yost and Wright 2001).

1.5 Benefits of maintaining habitat quality and connectivity

Maintaining habitat connectivity will not only benefit plants and wildlife, it will also benefit society by reducing costs related to public safety. For example, when roads fragment habitat, wildlife-vehicle collisions increase (Child 1997). Therefore, both actual and opportunity costs associated with protection and restoration of species and their habitat can be minimized through proactive planning. Furthermore, if game populations decline in response to habitat fragmentation, hunting opportunities may decrease, especially near access points. With continued impacts from habitat fragmentation, populations may decline and species may become at risk of extirpation or extinction (Bascompte and Solé 1996, Blaustein 1994, Fahrig 1997, With and King 1998), requiring measures to restore healthy populations that may be expensive and unpopular.

In many places, it is too late to do anything but protect what is left following fragmentation (Saunders et al. 1991). However, we in Alaska have a unique opportunity to identify and protect habitat and habitat connectivity before anthropogenic changes to the landscape isolate wildlife populations. The ADOT&PF can benefit from the information generated during this project by reducing the negative effects of habitat fragmentation and employing new technologies that make meeting this goal possible.

2.0 BUILDING THE TOOLBOX

2.1 Introduction

The toolbox described above needs to contain several important pieces of information including:

1. Whether Alaskans are concerned about the effects of roads on habitat quality and connectivity, and if so for whom and for what reasons;
2. About what species and areas people are concerned;
3. What direct and indirect effects roads and their related infrastructure have on habitat quality and connectivity for species and areas of interest;
4. Literature, especially literature pertinent to Alaska, related to the effects of roads on habitat quality and connectivity; and
5. Geographic Information System (GIS) data and methods that can be used by transportation planners to inform the road design process by promoting more sensitive road design that minimizes the negative effects of roads on species and areas of concern.

To build this toolbox, members of the project team assembled (1) a list of individuals interested in the effects of roads on habitat quality and connectivity in Alaska, (2) literature related to this issue and pertinent to Alaska, and (3) GIS data sets and methods useful to transportation planners for project development.

Additionally, we conducted two workshops the purpose of which were to (1) inform our research by taking the collective pulse of the community with regard to this issue, (2) identify gaps in our research, and (3) gather specific information including:

- Statement of topic and relevant issues
- Identification of species and geographic locations of interest
- Identification of direct and indirect effects of roads and related infrastructure on habitat quality and connectivity for species and areas of interest
- Identification of data sets necessary to develop a project GIS
- Identification of domestic and international jurisdictions, agencies, and NGO’s interested in the topic or undertaking similar work
- Identification of potential study areas
- Plan of action for future work

2.2 Interested parties

Initially we identified people to contact by performing a preliminary review of Alaska-based wildlife and habitat literature, Internet searches, and brief conversations with resource managers. We contacted interested parties by email and telephone. Each person was asked to refer other people with expertise and interest in the project.

We created and maintained a spreadsheet that lists all contact information including the person's phone number, mailing address, email address, area of expertise, referrals, whether the person wanted to be on the project email list and was able to attend workshops, and conversation-related notes. Additionally, we noted if the initial contact referred another person in the office more qualified to participate in the project. For example, Native representatives were initially identified by Internet searches for Lands Officers at each regional corporation. Often, the person listed on the corporation website would identify someone else who had a particular interest in GIS or habitat related issues.

2.3 Literature review

We searched local library and large-university databases to locate literature (e.g., journals, books, and agency reports) that helped identify possible effects of roads on habitat quality and connectivity in Alaska. We also located websites that described the work of non-profit organizations, state governments, and academic institutions with respect to this topic.

References were catalogued in an EndNote® bibliographic software library. Keywords were assigned to references in order to make classification and searches more efficient. We also created a spreadsheet of references that includes author, year, title, reference type, whether an Adobe Portable Document Format (PDF) document is available, associated website, and whether the abstract is included in the EndNote® database.

2.4 The role of GIS

GISs are computer-based systems used to organize, manage, and analyze spatial data. GIS enables analysts to create a model of the real world by layering geographic information (Fig. 1). Additionally, analysts can integrate common database operations and powerful spatial analysis techniques to combine spatial data in such a way to answer specific questions. Subsequently, transportation planners can use maps created as the result of analyses as decision-support tools for particular projects or to set policy.

In addition, use of GIS enables transportation planners to consider site features at multiple spatial scales. For example, at a coarse scale planners may want to view an entire management area, such as a transportation planning district. Alternatively, at a fine scale planners may focus on a three-mile stretch of road or the area where a road crosses an anadromous fish stream. By analyzing potential projects at a coarse scale, planners may be able to identify landscape patterns including vegetation characteristics, landforms, and hydrography that constrain project development. Alternatively, analyzing specific aspects of a project at a fine scale may be more desirable to identify areas of ecological importance, and evaluate the potential impacts of habitat fragmentation on a particular species or suite of species.

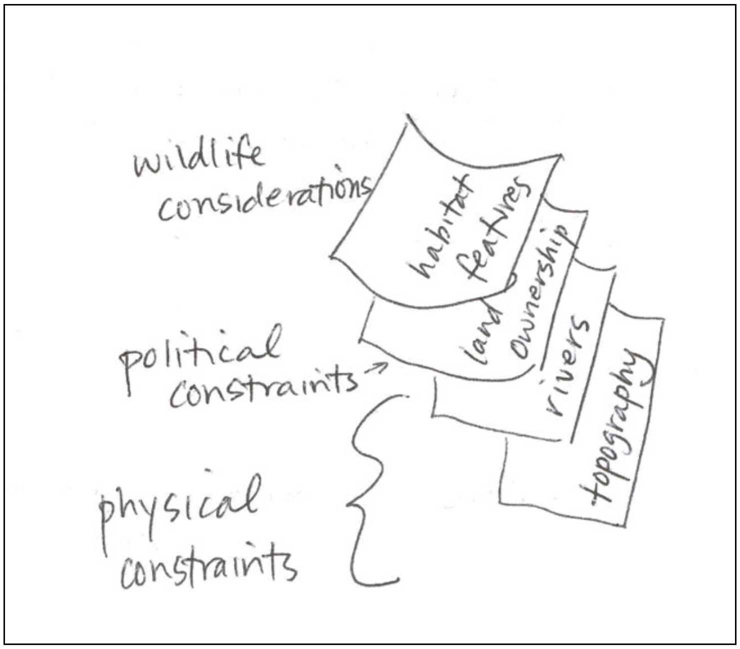

Figure 1. Layering data in a GIS for planning purposes.

Using GIS in the transportation planning process can make the project design process more cost-effective as reasonable alternatives can be identified before project-specific survey work begins. Analysts can use GIS to identify the physical constraints of proposed projects then overlay habitat features that may be important for one or more species. Consequently, transportation planners may be able to design and locate roads to minimize adverse effects to certain species and landscape characteristics, as well as the social and economic fabric of nearby communities.

We developed a GIS data library by collecting data sets from many cooperators (e.g., Native corporations, federal and state agencies, and NGOs). All data sets we collected were converted to ArcInfo coverages and grids in a common spatial reference system[1].

2.5 Workshops

Two workshops were organized to bring experts together for discussion and information sharing. Participants were asked to identify particular species and areas they were concerned about. Additionally, they identified direct and indirect effects of roads on habitat quality and connectivity for those species. Both workshops were held at the BP Energy Center in Anchorage, Alaska.

2.5.1 June 26, 2003 workshop

This workshop was scheduled for two hours and was designed to introduce the scope of the project, enlist the support of cooperators, and to acquire preliminary information to guide our research process. At this workshop, fifteen participants discussed:

[1] Albers equal-area conformal projection, North American Datum of 1927, 1st standard parallel 55^{o}, 2nd standard parallel 65^{o}, Central meridian –154^{o}, Latitude of origin 50^{o}, Units are meters.

- Whether people are concerned about the effects of roads on habitat quality and connectivity in Alaska;
- Issues related to roads and connectivity; and
- Effects of roads on habitat quality and connectivity in Alaska.

Participants also identified individuals from agencies, non-profit organizations, industry, and Native corporations to invite to the second workshop, which was to be held in September. We investigated all of the leads that resulted from the workshop, and continually updated our contact list as more information became available.

The PowerPoint presentation used during the workshop, list of participants, and summary of the workshop are available on the project website (http://www.akhcp.org).

2.5.2 September 26, 2003 workshop

Twenty-eight people attended this full-day workshop, which was facilitated by Margaret (Meg) King from the Environment and Natural Resources Institute at the University of Alaska Anchorage. We strove to identify and invite to this workshop people from organizations that were under-represented during the June workshop.

Each member of the project team presented a detailed overview of the information collected over the past several months. This included a review of information gathered during the June workshop, organization and format of relevant literature, acquisition, format, and organization of GIS data sets, and outreach activities. Our intent was to give workshop participants an opportunity to provide feedback on information collected, contribute new information, and identify gaps in information.

The PowerPoint presentation used during the workshop, list of participants, and summary from the workshop are available on the project website (http://www.akhcp.org).

3.0 RESULTS

3.1 Contacts

We identified 150 individuals concerned about the effects of roads on habitat quality and connectivity. These individuals included resource managers, biologists, ecologists, GIS experts, members of the public, as well as representatives from Native groups, federal and state agencies, and non-governmental organizations (NGOs) interested in contributing to the scoping analysis.

3.2 Search and review of relevant literature

We identified 628 peer-reviewed journal articles with information pertinent to Alaska regarding the effects of roads on habitat quality and connectivity. We also identified 272 books and reports that are relevant. We located 180 articles in PDF format and identified 27 relevant websites. Additionally, we identified numerous theses, magazine and newspaper articles, and online publications that combined with journals, reports, and books account for 996 references. All references and websites were categorized into general topic headings such as wildlife, water quality, soils, and connectivity.

3.3 Collection of GIS data sets

Examples of data sets we collected include:

- Digital Elevation Models (DEMs);
- Digital Line Graphs (DLGs);
- Digital Raster Graphics (DRGs);
- A seamless mosaic of DRG quadrangles for the entire state; and
- All available National Wetland Inventory (NWI) quadrangles for Alaska.

Additionally, we collected GIS-related contacts and websites where data sets useful to this project are available.

3.4 September workshop

Workshop participants shared issues and concerns regarding the impacts of roads on habitat quality and connectivity. Specifically, they focused on identifying concerns special to Alaska. Participants listed general characteristics that could be used as selection criteria to identify species and areas of highest priority and discussed species and geographic areas for which habitat connectivity is a concern. Additionally, we solicited information regarding contacts, literature, and GIS data sets to fill in gaps in our research. A photo gallery from the workshop is located in Appendix C.

The following sections summarize the input provided by workshop participants. For a more detailed review of participant input, please consult the workshop summary (http://www.akhcp.org).

3.4.1 Concerns

Participants brainstormed a list of concerns related to the effects of roads on habitat quality and connectivity including:

- Issues related to induced or secondary development resulting from road improvements or construction of new roads.
- Effects related to loss of habitat effectiveness. That is, the effective loss of habitat due to degradation. This may include effects of noise, light, dust, and physical changes in vegetation composition or stream width.
- Effects related to gravel roads versus paved roads.
- Issues related to gap-size tolerance. That is, issues related to variation in total road footprint including right-of-way and road width.
- Issues related to the inability to account for the economic value of ecosystem services affected by roads.
- Effects of constructing new roads before jurisdictions have the ability to institute land use planning or that minimizes effectiveness of future land use planning.
- Effects related to the construction of bridges and culverts including bridge span and height, and culvert diameter, material, and length.
- Effects related to road-related structures including fences and outbuildings.

3.4.2 Direct and indirect impacts of roads

Participants identified a number of direct and indirect impacts of roads on habitat quality and connectivity including:

- Direct mortality to wildlife
- Dust from unpaved roads
- Increased speed and volume of traffic associated with paved roads
- Habitat loss and fragmentation
- Impediments to movement
- Reduction in habitat quality
- Forest gaps
- Reduction in water quality
- Noise
- Changes in the flow of surface and ground water (wetlands)
- Light pollution
- Spread of exotic and invasive species
- Increased predation
- Access by humans and increased human activities that previously did not exist

3.4.3 Concerns special to Alaska

Alaska differs from many places with regard to population size and density, road density, age of the road network, climate, diversity and abundance of wildlife, and relative state of development. Participants identified a number of biological, physical, and social/cultural concerns special to Alaska and cautioned that there may be differences related to research conducted in the lower 48 states and elsewhere in the world. Additionally, they indicated that Alaska lacks data sets common in other states and countries.

3.4.3.a Biological concerns

Biological concerns special to Alaska include:

- Intact populations of fish, large predators, and migratory animals
- Small windows of time for activities such as breeding and raising of offspring
- Wide-ranging and migratory species
- Habitat specialists
- General absence of exotic and invasive species
- General absence of anthropogenic fragmentation
- Ability to easily isolate populations through anthropogenic fragmentation

Participants also noted the large diversity of ecosystem types in Alaska and unknown biological differences among areas studied elsewhere make statewide generalizations difficult.

3.4.3.b Geographical/physical concerns

Alaska's landscape is generally roadless and, for the most part, rivers are undammed. Permafrost and the northern climate imply that the effects of global climate change may have greater impacts in Alaska than places at lower latitudes. Because glaciers have only recently receded, the landscape is still relatively "new" and is being formed. However, some areas are heavily roaded and create bottlenecks for movement between patches of habitat.

3.4.3.c Social/cultural concerns

People in Alaska are highly dependent on use and extraction of natural resources for sustenance and economic viability. Establishing road access into previously unroaded areas increases use of off-road vehicles, poaching, and potential collisions with large animals such as moose and bears. Because many cities and boroughs in Alaska generally lack comprehensive land use planning, impacts associated with roads can be magnified by ancillary development.

3.4.3.d Data availability concerns

Because of Alaska's size and remoteness, there are concerns regarding data gaps. For example, Alaska lacks a consistently classified, satellite derived, fine-scale vegetation data set.

3.4.4 Species of concern

Several criteria helped to determine which species are important to consider in future analysis of roads and habitat connectivity. These include:

- Species valuable to humans
- Species that play an important role in wildlife communities
- Habitat specialists
- Species vulnerable to extinction
- Species with large home ranges or that forage over large areas
- Species practical to research because of existing data and knowledge

The following is a list of species that meet these criteria:

- Migratory birds including:
    - Shorebirds
    - Waterfowl
    - Forest songbirds, raptors, and passerines
- Anadromous fish (e.g., Coho salmon (*Oncorhynchus kisutch*))
- Fish indicator species including grayling (*Thymallus arcticus*)
- Terrestrial and aquatic insects
- Ungulates including:
    - Moose
    - Caribou
    - Sitka black-tailed deer (*Odocoileus hemionus sitkensis*)
- Predators including:
    - Black bear (*Ursus americanus*)
    - Brown bear
    - Red fox (*Vulpes vulpes*)
    - Wolverines (*Gulo gulo*)
    - Wolves
    - Lynx (*Lynx canadensis*)

- Amphibians
- Marine mammals
- Exotic and invasive species

3.4.5 Geographic areas of concern

Several criteria helped to identify geographic areas of concern including, (1) areas where good data on habitat features currently exist and that represent the diversity of ecosystems and road status in Alaska, (2) riparian corridors (e.g., habitats for aquatic and riparian-dependent species), (3) places where funding can be leveraged (i.e., work can be combined with other projects), and (4) places that can provide a source of baseline data.

Geographic areas that met the selection criteria included (Fig. 2):

- Nuiqsut
- Dillingham
- Southern Southeast: Prince of Wales Island
- Northern Southeast: Haines, Juneau
- Wasilla to Talkeetna
- Copper River basin – McCarthy
- Kenai Peninsula
    - Kenai National Wildlife Refuge
    - Cooper Landing

Areas that contain existing or proposed roads that met the selection criteria included (Fig. 2):

- Yukon River Highway
- King Cove Road
- Williams Port Road
- Parks Highway
- Parks-Glenn Highway interchange
- Roads near Denali National Park
- Dalton Highway
- Sterling Highway

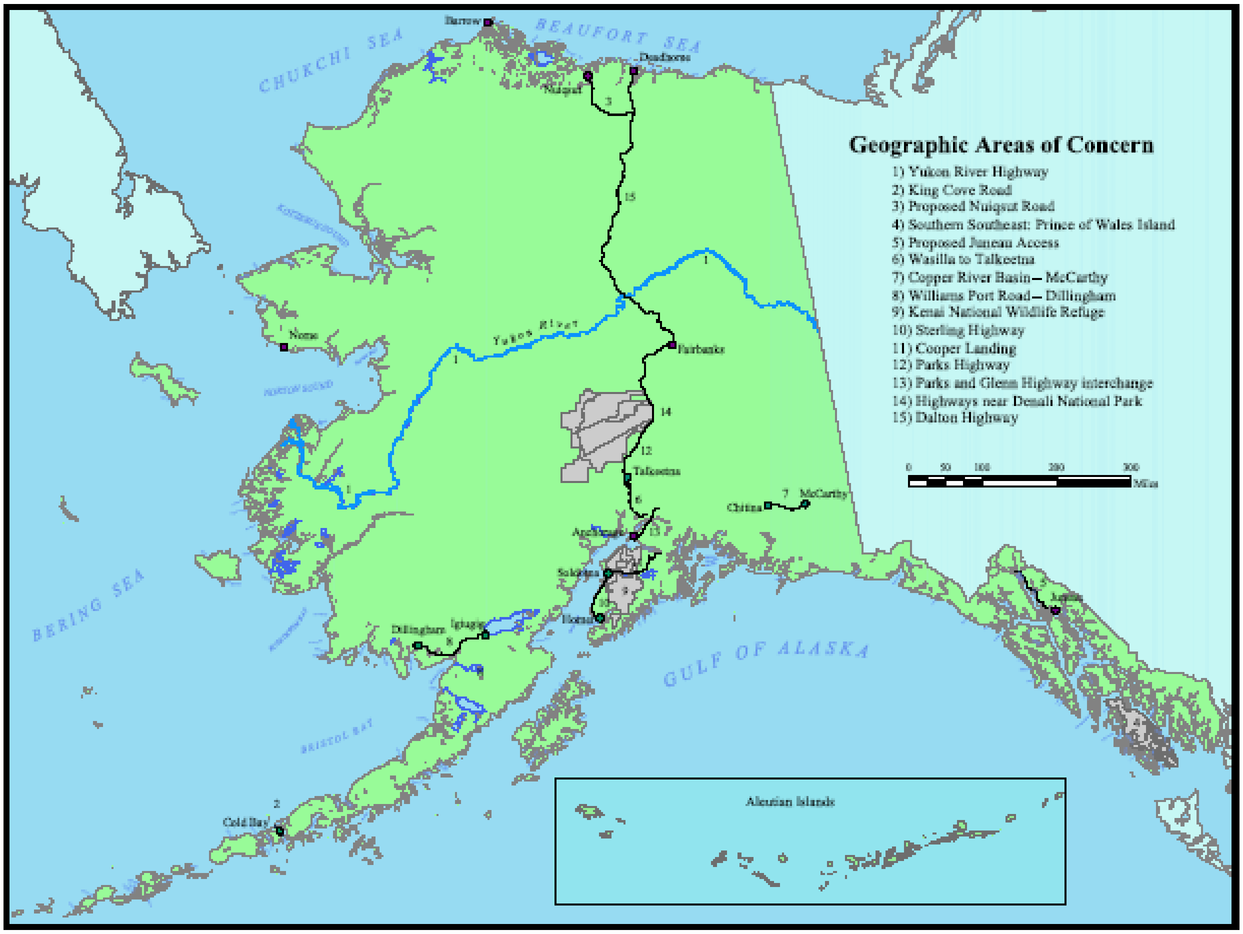

Figure 2. Geographic areas and road corridors of concern.

3.4.6 GIS data sets

Participants identified GIS data sets useful to planners during project development. Some data sets are already available, however some need to be created. Data sets include:

- DEMs
- Hydrology
- Geomorphology
- Traditional land use areas and cultural sites
- Impervious surfaces
- Hazardous material spills and how materials are moving into ground and surface water
- Salmon spawning and rearing areas
- Natural hazards (e.g., floodplains, avalanche chutes, eroding bluffs, fault lines)
- Surface pipelines
- Mortality (e.g., road kill locations)
- Roads
- Species distribution
- Road and other easements
- Land cover and vegetation

3.5 Project website

We created an open-access website that contains searchable databases of contact information, literature, and GIS data, as well as workshop summaries, miscellaneous documents, and the final project report. Visitors to the website can search databases using simple keyword searches, for example searching contact information by agency, literature by author, or GIS data by region. The website can be found at http://www.akhcp.org.

4.0. RECOMMENDATIONS

Most roads in Alaska were built before research on habitat connectivity existed. However, because of this study and other efforts, all individuals who contributed to this project felt that future road projects should consider impacts to habitat quality and connectivity in the planning process.

Our research and information provided at the two workshops have generated a number of recommendations. Consensus was that future research on the effects of roads on habitat quality and connectivity should leverage available funds; represent geographic, species, and project diversity; be proactive; make use of existing data; and study habitat features special to Alaska (e.g. anadromous fish, top-level predators, and roadless areas). Research should also aim to create products that can be used to make considerate land-management decisions.

With continued funding, habitat connectivity research could provide an effective means to:

(1) Programmatically develop access to necessary data for planned road projects and future pilot studies;
(2) Enable a proactive means to address the effects of roads on connectivity, as well as a cost-effective means to identify mitigation measures for existing impacts of concern;
(3) Develop useful and applicable documentation to analyze current and future road projects; and
(4) Create the ability to streamline the road design process by providing data and expertise to minimize negative effects of roads on habitat quality and connectivity.

The following sections provide examples of how information collected in this project can be used for future studies of habitat connectivity in Alaska.

4.1 Using the contact list

The contact list of experts compiled for this study includes people who are willing to participate in research and planning efforts. Transportation planners should contact experts before planning future projects.

4.2 Using the literature database

A wealth of information about how roads influence habitat quality and connectivity already exists. Therefore, for each proposed project, transportation planners should perform a review of existing information in the literature database created during this project. A review should critically compare and contrast findings from published research. If appropriate, information identified during the literature review can then be used to help construct GIS models.

The following case study regarding the effects of roads on wolves provides an example of what a summary report could entail for species potentially affected by a proposed project.

4.2.1 Effects of roads on wolves

Studies in northern Minnesota, Wisconsin, British Columbia, and Alaska have been conducted to determine the effects of roads on wolf populations. These studies date as far back as 1926 and have sample periods ranging from 2 to 34 years. In these studies, habitat selection and population dynamics have been compared with road density in order to derive a threshold of development over which wolf populations begin to decline. An early study by Robert P. Thiel of the University of Wisconsin found that "wolf populations failed to survive when road densities exceeded 0.93 mile/mile^2 [0.58 km/km^2]" (Thiel 1985). David Mech, a renowned wolf biologist who conducted research in Minnesota, found that a significant difference in mortality rates existed between an area of high road density (0.73 km/km^2) and a roadless area. In this study, the vast majority of wolf mortalities were caused from traffic collisions; however, trapping caused several deaths as well. Mech (1989) noted that within a 17-year timeframe, 69% of the wolves in his study were killed as a result of human interactions. Another study conducted by Mech et al. (1988) found that road density and wolf populations were inversely correlated below the 0.58km/km^2 threshold determined by Thiel (1985) and Jensen et al. (1986). The idea of a threshold is therefore subject to further confounding variables. Merrill (2000) found that traffic speeds and abundance might determine wolf behavior to a further extent than road presence. Merill's research suggested that roads with light traffic were often used as travel corridors. Another study headed by Thurber et al. (1994) substantiated this point by suggesting that wolves utilized gated pipeline access roads and secondary gravel roads for dispersal.

In addition to the general effects of roads, human disturbance has been examined with regard to wolf dens. These effects are germane to the impact of roads because highways and gravel roads alike provide increased access to previously inaccessible areas. However, the findings concerning human disturbance of wolf dens are not as conclusive as general road effects. Chapman (1979) found that wolves were able to detect humans within 1.6 km of their dens. They expressed their recognition through howling and barking. Wolves detected human presence within 2.4 km of dens with pups. In forested regions, these distances were reduced to 0.4 km (Chapman 1979). However, a more recent study conducted by Thiel et al. (1998) found that some wolves demonstrated substantial tolerance to human presence, traffic, and even explosives. These wolves demonstrated habituation to human disturbance within 0.5 km of den and rendezvous sites. Human impact on den sites is therefore an area requiring further investigation.

Another consequence of road construction is the increased access for snowmobiles. A recent study by Creel et al. (2002) indicated that snowmobile abundance was correlated with glucocorticoid presence in wolf physiological systems. Glucocorticoids are used as a stress correlate and have been related to reproductive problems. A corresponding reduction in snowmobile use was associated with a 37% decline in glucocorticoid levels (Creel et al. 2002). Snowmobile use is widespread in Alaska; therefore, impacts may be of special concern to road planners and designers. Although quantifiable displacement distances are absent from the literature, a study published by Bury (1978) found that the major effects of snowmobiles on wildlife are due to changes in daily routine and movement patterns.

In order to address the effects of roads on wolves, models depicting wolf habitat preference have been developed in Golden Canyon, British Columbia, Canada, the Adirondack Mountains of New York, and the northern Great Lakes region. In general, wolf habitat preferences are modeled using GIS in order to determine areas of potential conflict between wolf populations and development. Mladenoff et al. (1995) conducted a regional landscape analysis of wolf habitat in the Great Lakes region. They suggested that road density and fractal dimension were the most significant variables determining wolf habitat quality. They also found that land ownership, land cover, human population, landscape diversity, and landscape dominance were significant variables in determining wolf habitat. Although this model was not used for transportation planning, a similar model developed in British Columbia shows how such a model may be use for such a purpose. In this study, Callaghan et al. (1999) generated a GIS model to determine probabilistic movements of wolves in the Golden Canyon region of British Columbia. This model was based on known wolf movements and physiographic and anthropogenic factors. This logistic regression model was used to identify areas of potential highway crossings. Mitigation techniques such as overpasses may be constructed at these points of intersection in the future; however, they have not been to date. Another GIS model generated by Harrison and Chapin (1998) delineates wolf habitat in the Adirondack region of northern New York. Again, this model was based on known movements and habitat data. They used this model to determine the extent of habitat fragmentation in the northern Adirondack Mountains. They also used the model to identify potential dispersal corridors between core habitats.

An examination of the available literature indicates that roads (whether major highways or dirt roads) can have a significant effect on wolf populations. However, the traffic density on these roads may be even more important in determining behavioral adjustments. Snowmobiles can also affect wolf populations, although the distance of these impacts is less documented. As transportation planners seek to minimize effects of roads on wolf populations in Alaska, the threshold densities determined by Jensen et al. (1998) may be a useful guide.

Transportation planners should make use of information in the literature to inform future decision-making; therefore, we recommend the development of a guidebook using relevant literature to assist in the transportation planning process.

4.2.2 Guidebook to assist with road design

Several workbooks on road design and development have been written including one by the FHWA (Federal Highway Administration 2000). However, a volume that incorporates previous work and details most current practices specific to Alaska would be ideal. Specific chapters could outline environmental considerations when (1) planning road locations, (2) building roads and associated infrastructure, and (3) restoring habitat on or near existing roads.

4.3 Using GIS data sets and methods

ADOT&PF should organize all data about existing and proposed roads in GIS databases. Analysis of these data sets should focus on assessment of direct and indirect impacts of roads on select species, effectiveness of restoration demonstration projects, and changes in ecological processes (e.g., animal movement, surface and ground water flows, and changes in species composition) in response to roads.

GIS data sets can be used to create analytical and predictive models. An analytical model can be used for spatial and statistical analysis of data. We have included a case study to introduce one type of analytical model that would be useful in the transportation planning process (See section 4.3.2). Predictive models can combine existing data with ‘rules’ about relationships between variables to estimate outcomes from an event or sequence of events. The following examples may be used to acquire baseline data to identify and adjust suitable rules that reflect Alaskan conditions in predictive models.

4.3.1 Assessment of direct and indirect impacts of roads on select species

Fragmentation by roads and associated developments may negatively affect select species. Organisms may lose habitat, suffer direct mortality, experience loss of genetic variation, or gain competition from exotic and introduced species. Each of these effects may be assessed through use of spatial analysis and predictive modeling. An example of such a project was a study of caribou headed by Cronin (1998) in the Prudhoe Bay region. This study employed GIS data sets to analyze caribou telemetry data in relation to various types of infrastructure.

In addition, habitat indices can be developed for individual species using vegetation, river, and landform data ranked by species use during different seasons (Fig. 3.). The Alaska Department of Fish and Game developed such models in the mid 1980s for numerous species in Alaska (Alaska Department of Fish and Game 1986). Although these models need to be updated, they may serve as a useful basis for predictive analysis.

Also, a comparison between roaded and roadless areas for each species can show how habitat use, mortality, and population differ in relation to the presence of roads. By combining the habitat-suitability models with information on the effects of roads, a predictive model can be developed to identify potential areas of impact.

Pilot studies can be performed in each of the three ADOT&PF planning regions to illustrate the utility of predictive models. Pilot studies may analyze:

1. Brown bears – Central planning region (Kenai peninsula)
2. Alexander Archipelago wolf – Southeast planning region (Tongass National Forest)
3. Caribou – Northern planning region (Arctic)

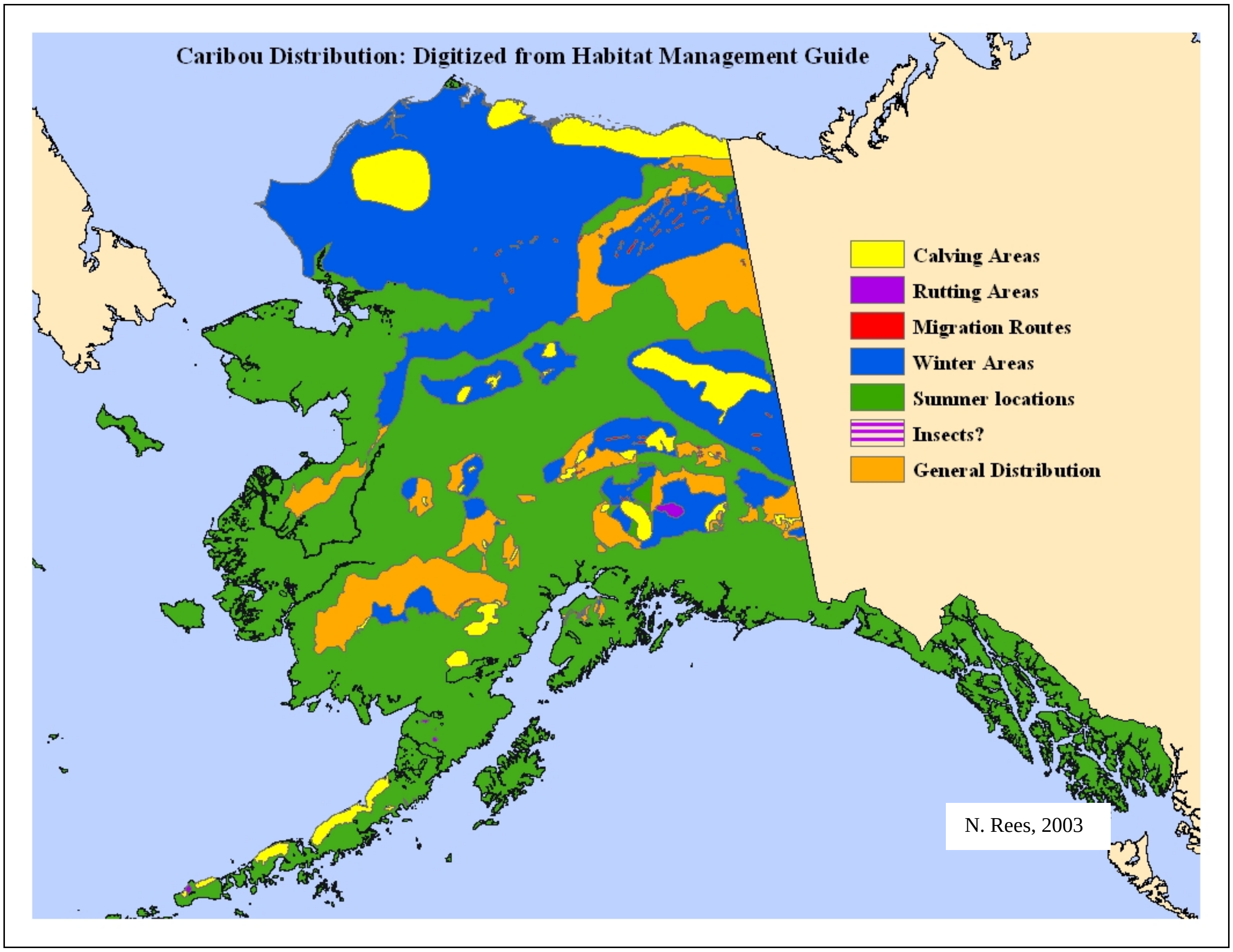

Figure 3. Caribou distribution in Alaska as delineated by the Alaska Department of Fish and Game in their 1986 Habitat Management Guide for caribou.

4.3.2 Analysis using a GIS to determine the relative effects of proposed road alignments through wetlands

The following hypothetical example of a proposed road from Chitina to Cordova illustrates how transportation planners can use GIS to minimize potential adverse effects on sensitive areas.

Planners can use a GIS to evaluate three alternative road alignments to determine which has the least affect on wetlands (Fig. 4) by performing a simple spatial analysis using the following methods:

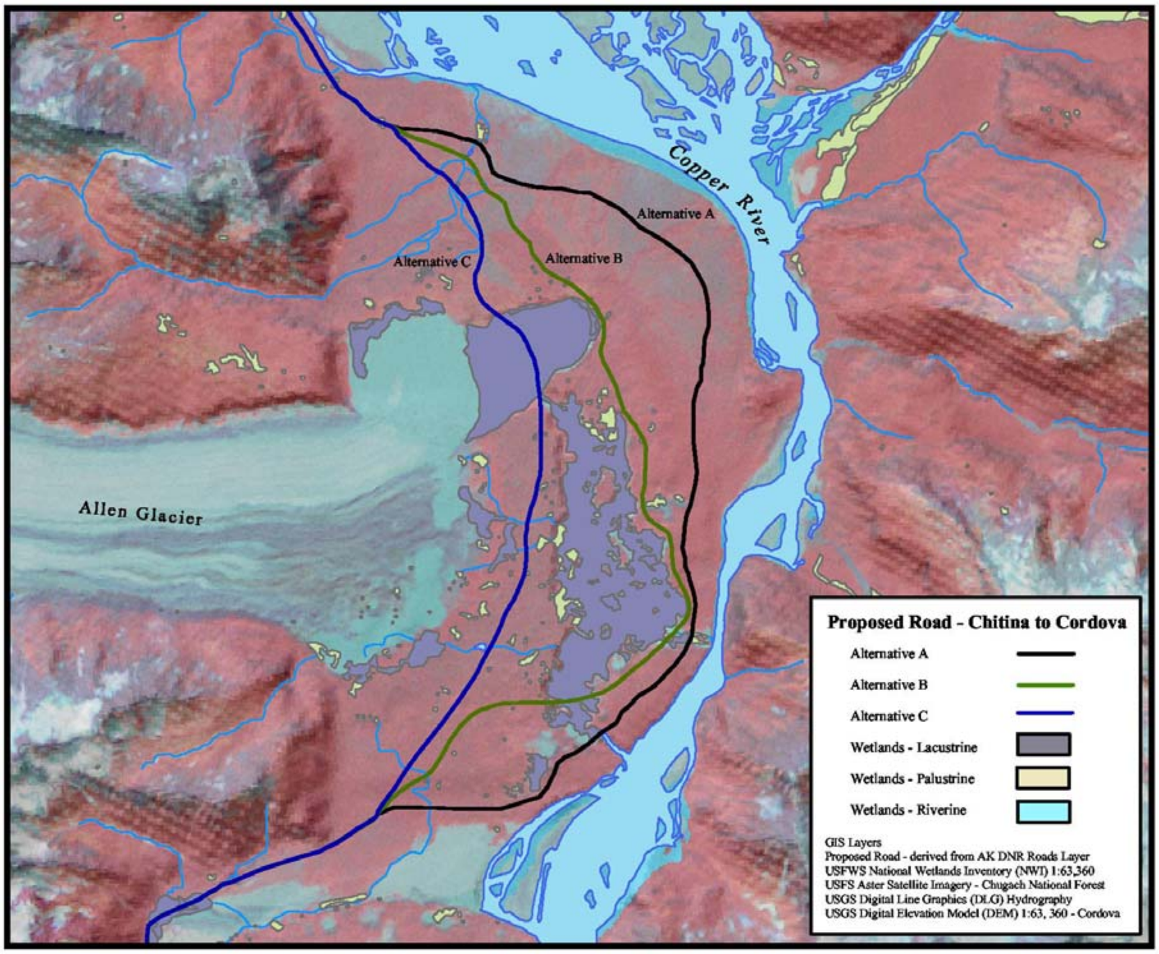

Figure 4. Three road alignment alternatives.

GIS data sets

- Proposed road alignments derived from the roads data set acquired from the Alaska Department of Natural Resources
- National Wetlands Inventory 1:63,360 scale data set acquired from the U.S. Fish and Wildlife Service
- Aster satellite imagery acquired from the Chugach National Forest
- Cordova quadrangle Digital Elevation Model 1:63,360 scale data set acquired from the U.S. Geological Survey

Methods

- Create a 300' buffer around each proposed route to simulate the area associated with the potential road corridor (Fig. 5)
- Use the buffer area to identify wetlands that are potentially affected by the road corridor (Fig. 6)
- Calculate the area of wetlands within the buffer of each alternative to determine the number of acres of each type of wetland within the road corridor (Table 1)

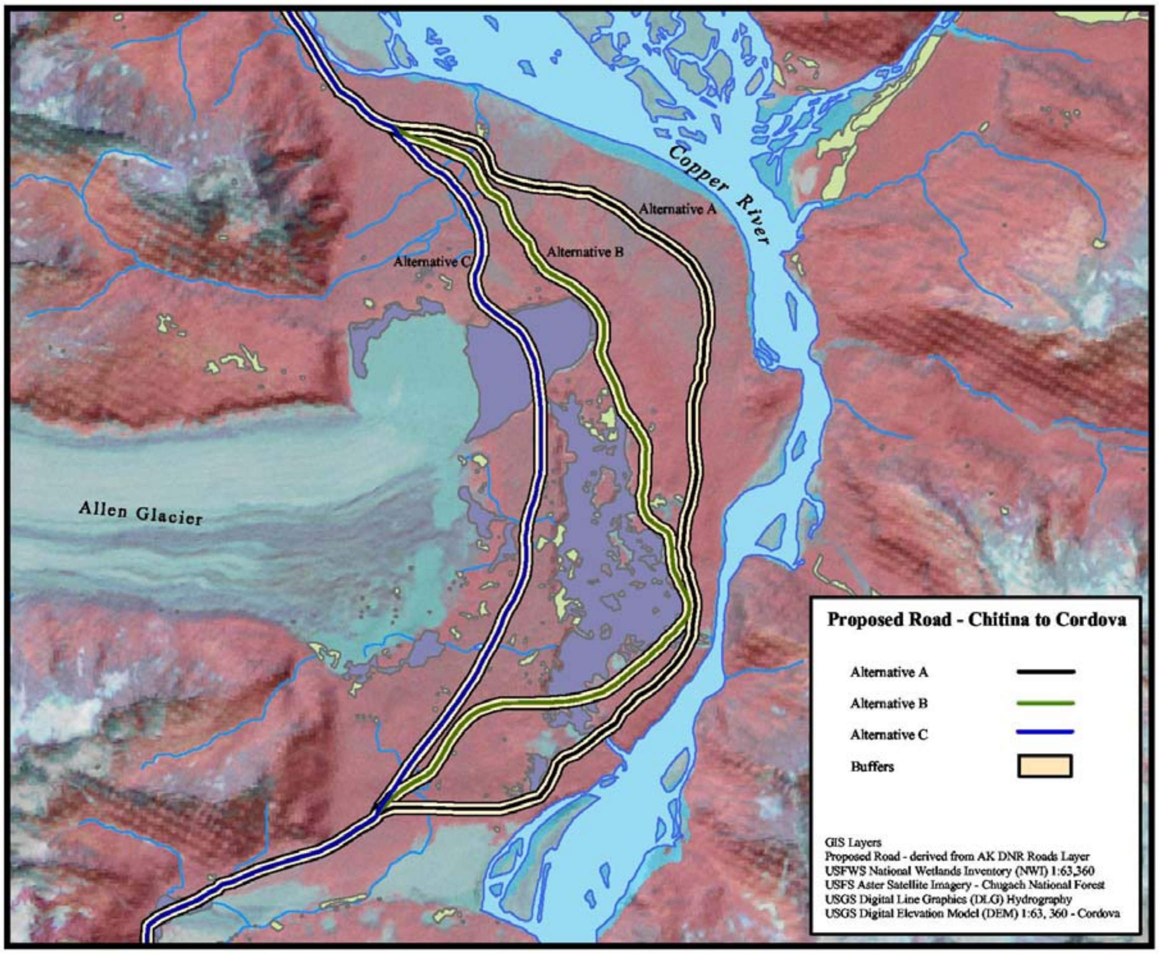

Figure 5. Buffer areas for each proposed alternative route.

Additionally, GIS analyses can answer other types of questions including the number of times a stream crosses each alternative, and miles of streams, type and area of land cover, and type and area of ownership affected by each alternative route.

4.4 Adding local and traditional knowledge

Local and traditional knowledge are valuable sources of information. However, they are generally not documented and are difficult to capture. The scope of this project did not encompass social considerations, but future studies should. Some mechanism should be found to systematically acquire local and traditional knowledge about direct and indirect effects of roads on people, and habitat quality and connectivity. We identified several sources where information regarding local and traditional knowledge has been previously collected (Table 2).

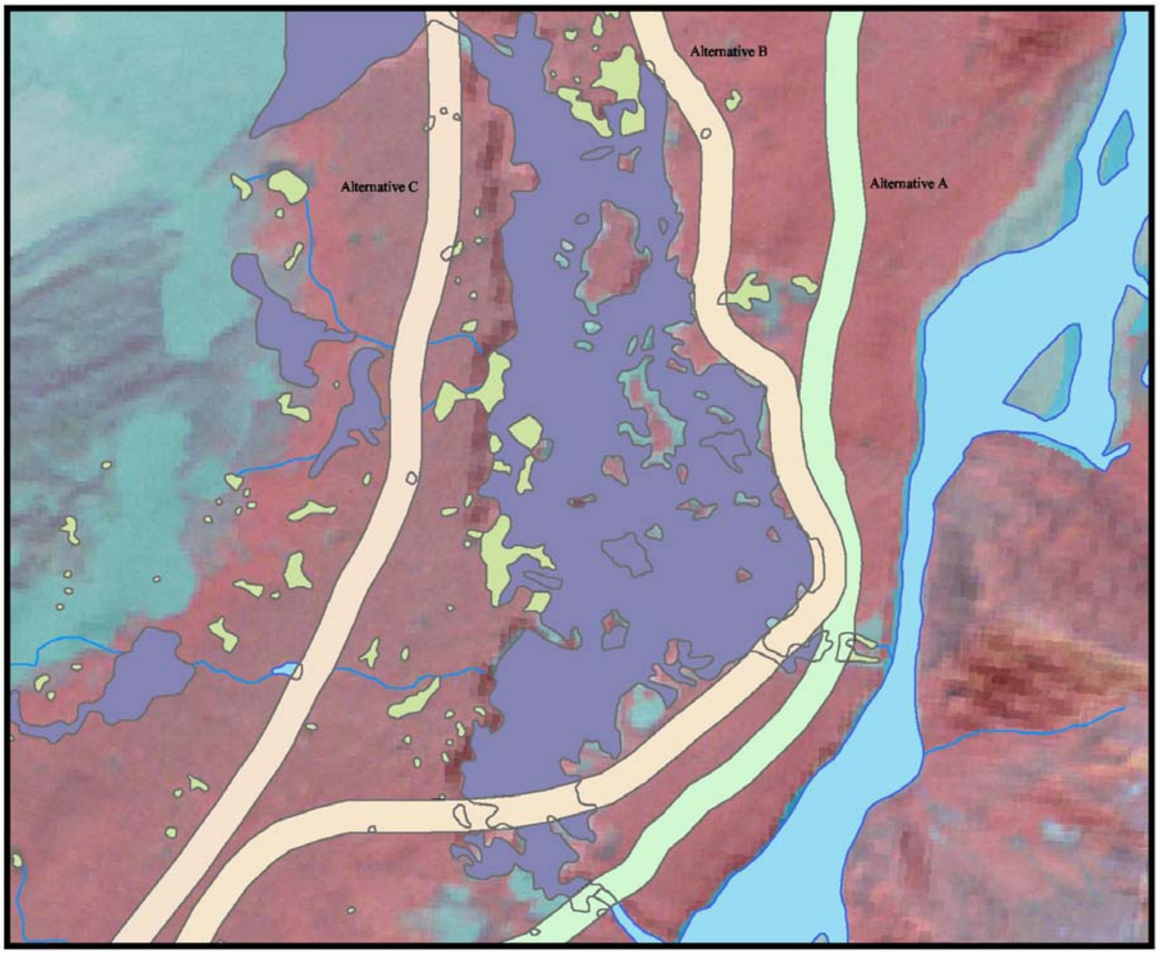

Figure 6. Wetlands that fall within each buffer area. As the buffer data set passes though the wetland data set, only the wetland areas that fall within the buffer are retained, everything else is ignored.

Table 1. Acres of wetlands affected by each alternative.

Wetland type	Alternative A	Alterative B	Alterative C
Lacustrine	71.8	104.3	128.9
Palustrine	13.8	15.1	12.5
Riverine	4.8	7.6	8.1
Total	90.4	127	149.5

Table 2. Sources of local and traditional knowledge in Alaska

Information Type	**Contact**	**Notes**
Alaska Native Knowledge Network	www.ankn.uaf.edu	Sponsored by the Alaska Federation of Natives, University of Alaska, National Science Foundation, and Alaska Department of Education
University of Alaska Library, Oral History Program	www.ankn.uaf.edu	
Traditional ecological knowledge (TEK) in Exxon Valdez oil spill areas.	www.fakr.noaa.gov/oil/default.htm and www.oilspill.state.ak.us	Exxon Valdez Oil Spill staff
State and Federal subsistence specialists	Mariann See, Deputy Director Alaska Department of Fish & Game, Subsistence Division	Years of data
Kachemak Bay Research Reserve	www.kbayrr.org	CD-ROM
Native American Rights Fund	420 L Street, Suite 505, Anchorage, AK 99501, 907-276-0680	
Minerals Management Service - MMS/OCS	www.mms.gov/alaska	Subsistence studies
Anecdotal information in EIS documents		Materials from scoping on particular issues. For example, environmental impact statements from the Red Dog Mine and airports.

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APPENDIX A

Project Team Biographies

John DiBari

John received his Ph.D. in renewable natural resources studies from the University of Arizona where he concentrated in landscape and wildlife ecology. John is currently an assistant professor of landscape ecology at Western Carolina University and an affiliate assistant professor at the Environment and Natural Resources Institute, University of Alaska Anchorage. He was the principal investigator for the habitat connectivity project. John's interests include researching the effects of natural and anthropogenic disturbances on the ability of animals to move within landscapes and acquire resources.

Jason Geck

Jason received a B.A. in economics and environmental studies from California State University, Sacramento and an M.S. in environmental science from Alaska Pacific University. Jason organized the GIS component of this project. He teaches GIS and Global Positioning System classes at Alaska Pacific University. Jason's research interests include landscape ecology and conservation GIS. Jason has a consulting business through which he has worked with local and state governments, Native corporations, and environmental consulting firms.

Natalie Rees

Natalie received a B.S. in environmental studies from the University of Utah. She is currently working on her master's degree in environmental science at Alaska Pacific University. Natalie spearheaded the literature review and provided logistical support for the workshops. Her main interests include the use of GIS in conservation design, biogeography, and community-based planning. She worked in water quality and social services prior to moving to Alaska.

Cheryl Van Dyke

Cheryl received her B.A. from Colorado College and M.S. from Alaska Pacific University. Both of her degrees are in environmental science. Cheryl organized the workshops and coordinated outreach activities in addition to preparing many of the written documents associated with the project. Her background is in wildlife research and cooperative program management. She runs a consulting firm and works on projects that range from community to remote area planning, with an emphasis on site analysis using GIS analysis and stakeholder interviews.

APPENDIX B

Glossary

Connectivity: The degree to which a landscape facilitates or impedes movement (Taylor et al. 1993). Linkages…at multiple spatial and temporal scales (Noss 1991).

Fragmentation: The breaking up of habitat into smaller disconnected patches (Turner et al. 2001)[2].

Gap tolerance: The size of gap, most likely an area of non-habitat, an individual is willing to cross.

Habitat: An area that possesses the resources necessary for an organism or population of organisms to carry out all or part of its life cycle.

Habitat connectivity: The actual connection of habitat patches, the connection of habitat patches by dispersal, or the perceived connection of the landscape by a species (With et al. 1999). This includes both terrestrial and aquatic habitat.

Habitat generalist: A species with a broad pattern of resource usage.

Habitat specialist: A species with a narrow pattern of resource usage.

Landscape: A heterogeneous, diverse land area (i.e., a mosaic) composed of interacting ecosystems (Forman and Gordon 1986).

Roads: Existing state highways both paved and unpaved. Development associated with roads, such as utility corridors, fences, outbuildings, and culverts. Areas with potential for future road construction should be considered in subsequent studies.

[2] Note that natural fragmentation exists in Alaska (e.g., streams, ice fields, and islands).

APPENDIX C

Photo gallery from September 26, 2003 Habitat Connectivity Workshop.

Figure 7. Participants listened to the project team review the information already collected.

Figure 8. All participants took part in a discussion focused on criteria for determining project priorities.

Figure 9. Bill Ballard, ADOT&PF and Jeff Heys, NPS used a workshop break for an in-depth conversation.

Figure 10. Participants met in small groups of 3-6 people to identify species and areas of concern using selection criteria established by the entire group. Additionally, small groups created a list of GIS data sets and brainstormed ideas for pilot studies to analyze habitat connectivity in Alaska.

Figure 11. Groups had lively discussions about which species were most important to study.

Figure 12. Group members worked individually before reconvening to discuss the results of their work.