WILDLIFE DATA-GAP ANALYSIS FOR THE PROPOSED SUSITNA–WATANA HYDROELECTRIC PROJECT

DRAFT REPORT

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TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

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INTRODUCTION

In November 2010, the Alaska Energy Authority (AEA) selected the Low Watana Project on the upper Susitna River over the Chakachamna Project as the better candidate for timely permitting and construction of a new hydroelectric project to supply a significant new source of electricity to the Alaska Railbelt region (AEA 2010). Advancing this project was determined to be a critical step for meeting the State of Alaska's goals to replace the dwindling contribution from Cook Inlet natural gas to the Railbelt's energy demands and to provide a significant new source of energy to decrease the state's dependence on fossil fuels in the coming decades. The Low Watana dam was one of the options designed as part of the Susitna Hydroelectric Project (SHP) proposed and studied extensively by the Alaska Power Authority (APA, the precursor to AEA) in the early 1980s.

ABR, Inc. was one of four contractors selected by AEA in December 2010 to compete for work orders under the Railbelt Large Hydroelectric Environmental Term Contract. ABR was awarded a contract to conduct the wildlife data-gap analysis for the Susitna Hydro Evaluation Project in late January 2011. The first objective of this analysis was to identify, compile, review, and synthesize both historical data from the original Susitna Hydroelectric Project (SHP) in the 1980s and more recent data collected since then on wildlife species and their habitats in the Susitna River basin. The second objective was to use that information to identify data gaps, which will be used to develop objectives for further study to support the Federal Energy Regulatory Commission (FERC) licensing process for the Low Watana Project, now known as the Susitna–Watana Hydroelectric Project (abbreviated WHP in this report). The potential data gaps identified in this report will need to be developed further, modified, and refined as the planning process for the licensing study evolves. Information needs that ultimately are determined to be worthy of further study will be based on analysis of project issues and the needs of the regulatory process.

This analysis focuses on the historical and current information available on the baseline (preconstruction) conditions of the existing environment and on identifying further information needed for the next phase of the FERC licensing process (the preliminary application document, or PAD). Although we recognize that some knowledge of potential impacts is needed to assess whether existing data are sufficient for the upcoming FERC licensing process, the probable environmental consequences of the WHP are not evaluated in this report.

The scope of this analysis includes terrestrial wildlife—mammals, including aquatic furbearers, and birds, including waterbirds—and their habitats, but excludes marine mammals. The Distinct Population Segment of beluga whale (*Delphinapterus leucas*) inhabiting Cook Inlet is listed as an endangered species and depleted stock under the Endangered Species Act and Marine Mammal Protection Act, respectively. Although belugas were included in the terrestrial studies program for the original SHP, that species is discussed in the separate data-gap analysis for aquatic resources (HDR 2011). This analysis includes vegetation, wetlands, and wildlife habitat evaluation.

PROJECT BACKGROUND

Construction of hydroelectric dams on the Susitna River had been discussed by various agencies since at least the late 1940s, but the concept began to be studied seriously by the late 1970s (Harza–Ebasco 1987). The SHP was the focus of an intensive multidisciplinary program of engineering and scientific studies, with preliminary work beginning in the late 1970s and a formal research program active in the first half of the 1980s (Harza–Ebasco 1987, AEA 2010, Hatch Associates 2010). The SHP originally was envisioned as a two-dam project on the upper Susitna River, involving construction of an 870-ft-high earth-fill dam just downstream from the mouth of Watana Creek, followed by a 635-ft-high thin-arch concrete dam located farther downstream at Devils Canyon (Harza–Ebasco 1987). APA drafted an Application for Major Project by November 1982 and filed it with FERC in February 1983 (Hatch Associates 2010). FERC subsequently released a draft environmental impact statement in May 1984 (FERC 1984).

By 1985, however, the state's ability to finance the project was decreasing due to declines in the price of oil, economic growth, and energy demand, leading APA to conclude that a phased three-part project was more economical. An amended application to FERC was prepared in 1985, proposing construction first of a 700-ft-high rock-fill dam near the mouth of Watana Creek (Low Watana), followed by an 635-ft-high concrete, thin-arch dam downstream at Devils Canyon, and finally by expansion of the Watana dam to the full proposed height of 870 ft (High Watana). As funding questions continued in 1986, the proposal focused on the Devils Canyon dam as the first stage of a two-dam scheme. Concerns about the financial viability of the project, stemming from the condition of Alaska's economy at the time, led APA to suspend the SHP in April 1986 and withdraw the FERC license application (Harza–Ebasco 1987, AEA 2010). By that point, the state had invested approximately $135 million in the project (Harza–Ebasco 1987).

As currently envisioned, the WHP would closely resemble the Low Watana dam (the first phase of the revised three-phase design of the SHP), consisting of a 700-ft-high earth-fill dam that would form a reservoir approximately 63 km (39 mi) long at about the 2,100-ft elevation contour, with an installed generation capacity of 600 MW (AEA 2010, Hatch Associates 2010). The conceptual engineering design currently includes several access options: (1) approximately 71 km (44 mi) of new road access south from the Denali Highway to the proposed dam site; (2) road or rail access from the Alaska Railroad corridor at Gold Creek, on the Susitna River about 60 km (37 mi) downstream from the Watana dam site; or (3) road access from the Parks Highway/Alaska Railroad corridor at Chulitna, on the north side of the Susitna River. Transmission lines would connect to the existing Railbelt power grid (Anchorage–Fairbanks intertie) near Gold Creek (Hatch Associates 2010), or possibly to both Gold Creek and Cantwell if the northern (Denali Highway) access route is selected.

STUDY AREA

The study area was defined broadly to encompass the entire Susitna River drainage basin (Figure 1), the proposed reservoir impoundment upstream of the proposed Watana dam, the floodplain areas that may be affected downstream as far as the mouth of the Susitna River, various alternatives for access to the Watana dam site from the Denali or Parks highways or Alaska Railroad, and transmission line alternatives from the Watana dam to the existing electrical power transmission system (Anchorage–Fairbanks Intertie).

In this document, three portions, or reaches, of the Susitna River are recognized, as defined at an agency meeting in the AEA offices on 21 April 2011:

- Upper—from the proposed Watana dam site upstream to the headwaters of the drainage;
- Middle—from the Watana dam site downstream to the confluence with Chulitna River, just upstream from the community of Talkeetna;

- Lower—from the Chulitna confluence downstream to the mouth of the Susitna River at Cook Inlet.

The upper and middle reaches are included in the Upper Susitna subbasin (Figure 1). More detailed descriptions of the river reaches is provided in the aquatic resources data-gap report (HDR 2011). It should be noted that the authors of the original SHP studies did not necessarily conform to this usage, and the terminology sometimes differed among SHP reports.

Specific study areas varied among the different species and taxonomic groups of wildlife reviewed for this report, depending on the distribution and movements of the taxa being studied. Although we recognize that wide-ranging species of wildlife may move seasonally among subbasins, information specific to the Chulitna and Yentna subbasins was not included in this analysis. The scope of the analysis focused primarily on the upper and middle reaches of the Susitna drainage and on the floodplain of the lower reach of the drainage. This breakdown corresponds generally to that used in the original SHP studies in the 1980s.

For the purposes of wildlife population management and reporting, the state of Alaska is divided into 26 game management units (GMUs). The Susitna River basin contains all or parts of GMUs 13E, 13A, 13B, 14A, 14B, 16A, and 16B (Figure 2), which are the primary reporting units for management and technical reports produced by the Alaska Department of Fish and Game (ADFG). For harvest reporting, GMU subunits are subdivided further into Uniform Coding Units (UCUs), consisting mainly of small drainage basins. The 136 UCUs in and near the entire Susitna River basin are not depicted in Figure 2 for the sake of clarity and simplicity, however. GMUs 13, 14A, 14B, and 16 historically were part of ADFG Region II, headquartered in Anchorage, but recently were incorporated into the new Region IV, headquartered in Palmer.

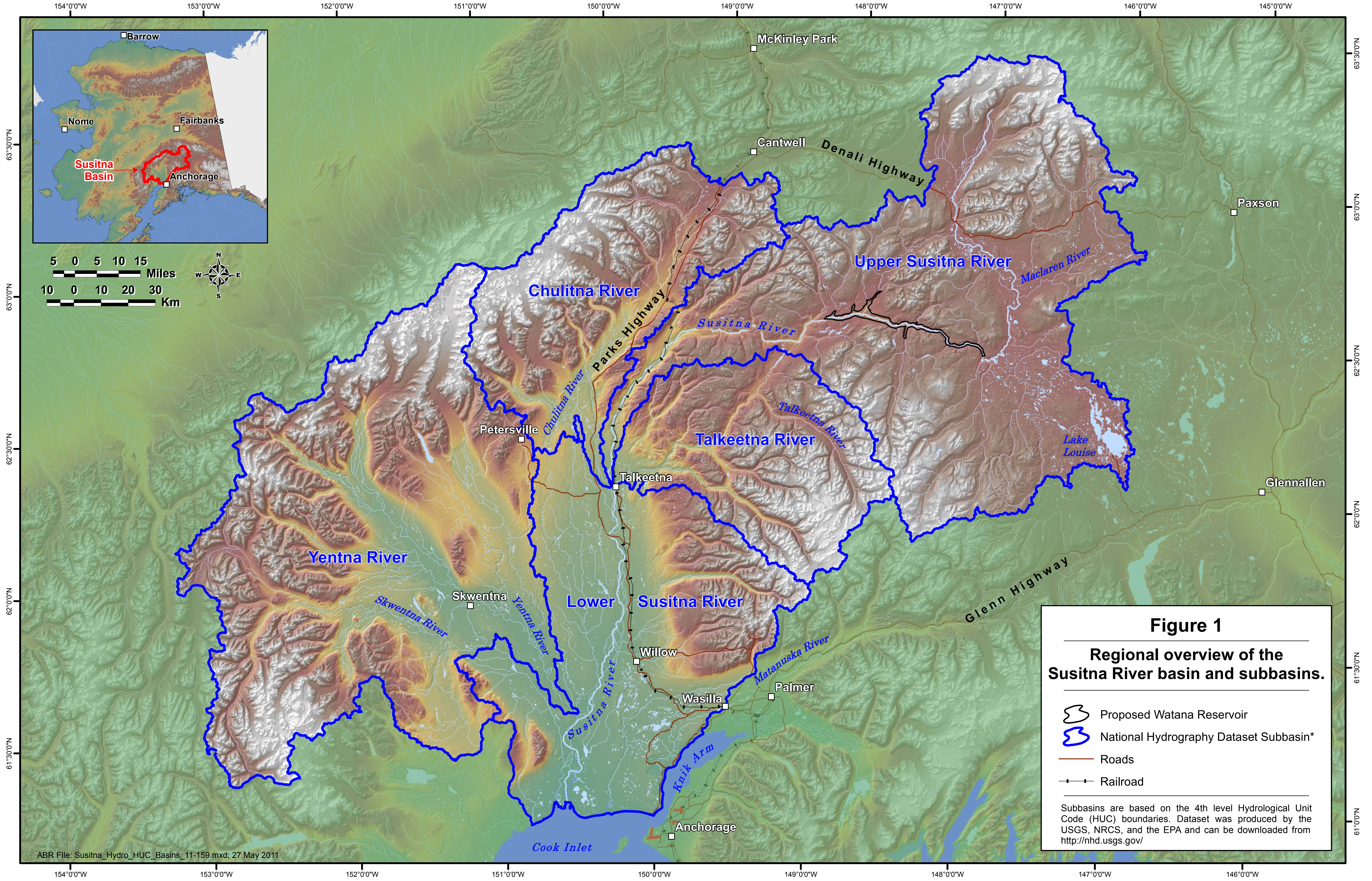


Figure 1

Regional overview of the Susitna River basin and subbasins.

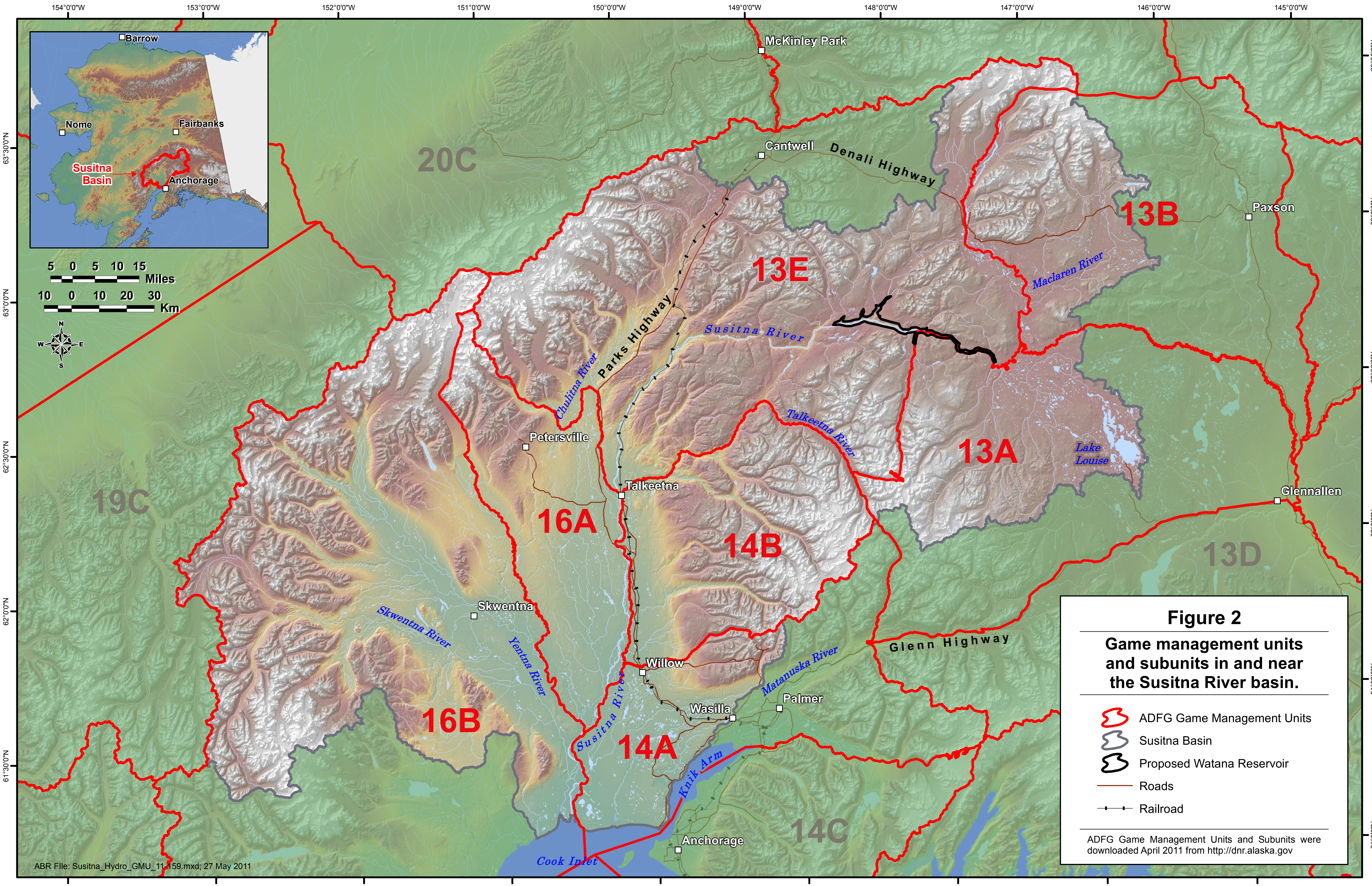


Figure 2

Game management units and subunits in and near the Susitna River basin.

METHODS

This analysis was exclusively a desk-top exercise; no field studies were conducted. The study goal was to identify data gaps and highlight information needs for use in developing a list of studies to accompany the PAD, which AEA plans to submit to FERC in fall 2011. The focus of the analysis reported here is terrestrial wildlife species (mammals and birds) and their habitats, incorporating information on vegetation, land cover, and wetlands.

The analysis began with a search of historical documents produced by APA's studies program for the SHP, which remains among the most intensive environmental research programs ever conducted in the state. The SHP resulted in the production of hundreds of documents, each of which was assigned an accession number (which are listed after entries in the Literature Cited section at the end of this report). The Susitna Records Management System (Harza–Ebasco 1987) was organized after the SHP was canceled, to preserve the extensive amount of information that was assembled and produced for that research program. Copies of the SHP documents were retained by the APA (which later became the AEA) in Anchorage and by the state archives in Juneau, which was given a complete set of microfiche copies, and many project materials (including data from various studies) were sent to the University of Alaska (UA) archives and library system (Harza–Ebasco 1987). AEA later donated their paper copies to the Alaska Resources Library Information System (ARLIS) and the UA library system, while retaining copies on microfiche (B. Carey, AEA, pers. comm.).

Initially, we used optical character recognition software to examine digitally scanned versions of document lists compiled soon after the original studies were completed (APA 1988a, 1988b). We selected for further evaluation a number of titles that were deemed relevant to the wildlife data-gap analysis. Later, we digitally searched a Microsoft Access database of approximately 3,400 document titles that HDR, Inc. had produced for AEA by scanning the same document list (APA 1988a) and using optical character recognition (OCR) software. In all, more than 200 historical documents that were considered to be potentially relevant were identified and requested from AEA. Microfiche copies of documents that had not been scanned previously then were scanned by a commercial vendor to produce digital copies. Copies of nearly all the documents we requested were provided electronically. During our review, we identified a small number of APA documents that had been assigned duplicate numbers and corrected other document information that had been entered incorrectly in the original database.

We conducted online searches of the University of Alaska library system catalog for SHP and related historical references for the Susitna basin. Other publications produced in the mid-1980s were valuable for this review, particularly ADFG's *Alaska Habitat Management Guides* series, which includes map atlases of species distribution, movements, and seasonal concentration areas for important life-history events. The Susitna Basin Area Plan produced by the Alaska Department of Natural Resources (ADNR) in the mid-1980s was examined with regard to management objectives for various wildlife species and the detailed mapping of selected wildlife species, vegetation, and habitats that was done for the basin. The Alaska River Basin Study program, another large collaborative research program that ran concurrently with the SHP program, began in the Susitna River basin in 1979 (USDA 1985a) and produced a substantial amount of information that was used in preparing the Susitna Area Plan.

Literature published more recently was located by searching ABR's in-house database compiled from *Current Contents on Diskette*, as well as by conducting internet searches using the Google Scholar web browser. For mammals, the most relevant recent information is produced by ADFG's Division of Wildlife Conservation, principally in the form of technical reports on specific research projects, management reports (produced at 2–3 year intervals for large mammals and furbearers), and annual performance reports. Useful for birds are the waterfowl breeding-pair survey reports produced by the U.S. Fish and Wildlife Service (USFWS), as well as reports produced irregularly by various agencies detailing raptor nesting surveys and breeding landbird surveys focused on migratory species, some of which have experienced population declines elsewhere in their ranges since the original SHP research program ended (those species are discussed later as species of conservation concern). The literature review included worldwide literature on hydropower developments, climate change, and their effects and implications for wildlife species and their habitats.

Nearly all of the SHP documents were produced in the first half of the 1980s. We reviewed the reports we considered to be relevant and compared that information with regional data on wildlife populations collected since the SHP ended. In addition, other recent literature was examined for changes in technology and research methods, environmental regulations, and species conservation status. The intent of these comparisons was to evaluate which of the findings of the SHP studies remain relevant today and are adequate to support the licensing process for the current project, in contrast to information that is out of date and needs to be updated for the current WHP. The results of the information review were combined to identify and summarize potential data gaps for review by, and discussion with, federal, state, and local resource and regulatory agencies to establish a set of objectives for further study to support the FERC licensing process.

We created a bibliographic list of documents selected for further examination. The documents deemed useful for analysis were cataloged and annotated in ABR's in-house literature database using *EndNote* bibliographic software (Thomson Reuters, version X4.0.2). The bibliographic database entries provided the primary information source for the synthesis stage of report preparation. As a starting point, we examined whether data gaps were identified for the original SHP program and, if so, whether those needs had been satisfied. We considered changes in species abundance, distribution, and regulatory and conservation status over the last quarter-century to evaluate whether older issues still persist and whether new issues have arisen since the original SHP program concluded. The focus of this phase of the work was to determine whether the historical data gathered for the original SHP are adequate to inform current analyses and to address current information needs for the WHP. Survey methods and research techniques used in the original SHP were compared with more recent technology (e.g., satellite and GPS telemetry, GIS) and population survey techniques.

Map figures were produced using data available from the Alaska Geospatial Data Clearinghouse (AGDC) and Geographic Information Network of Alaska (GINA), as well as GIS base-map layers maintained in-house at ABR.

INFORMATION REVIEW

Extensive studies of a broad variety of wildlife species were conducted in the Susitna River basin in the first half of the 1980s for the original SHP study program. Field surveys focused primarily on mammals—moose, caribou, Dall's sheep, brown bear, black bear, wolf, wolverine, beaver, other furbearers, and small mammals—and were conducted mostly by ADFG, the University of Alaska Museum, and the Alaska Cooperative Wildlife Research Unit, at the University of Alaska–Fairbanks. Field surveys of birds—raptors, waterbirds (swans, geese, ducks, loons, grebes), shorebirds, and landbirds (mainly terrestrial songbirds)—were conducted by the University of Alaska Museum and later by LGL Alaska Research Associates, Inc. Mapping of vegetation was conducted for the original SHP by researchers from the University of Alaska–Fairbanks Agricultural Experiment Station (later renamed the Agricultural and Forestry Experiment Station) and by Ray A. Kreig and Associates, to provide a basis for quantifying project impacts on vegetation, wetlands, and wildlife habitats. The reports detailing these various baseline studies are cited below in the body of this report.

Besides the original and amended FERC applications (APA 1983, 1985), several references provide useful summaries of the SHP terrestrial studies: the overview by Harza–Ebasco (1986), study plans (Harza–Ebasco 1984a, 1985), the draft mitigation plan prepared for the SHP (LGL 1985a), and summary matrices of potential impacts and mitigation (LGL 1985b). Harza–Ebasco (1986) provided an annotated description of the studies undertaken in both Phases I (1980–1981) and II (1982–1983) of the SHP terrestrial studies program. The document describes the studies conducted for each topic or species, a listing of citations with specific information, and a list of references. Although results are not discussed, that document is a useful guide to the reports that describe the methods and results of the SHP terrestrial studies. The study plans (Harza–Ebasco 1984a, 1985) are instructive with regard to data gaps because they provide insights into topics that were judged to require further study after the Phase I and Phase II studies ended.

The original FERC application for the SHP (APA 1983) and the amended application (APA 1985) provide good summaries of the information obtained from baseline studies, as well as analyses and ranking of impacts and analysis of mitigation options. The SHP impact assessment and mitigation summary (LGL 1985b) is not reviewed in detail here because our focus is on the adequacy of baseline information regarding the existing environment, rather than a discussion of potential project impacts and environmental consequences. That document provides a valuable compilation of information from the extensive work that went into identifying likely impacts and developing mitigation plans. A substantial effort was expended to create a mitigation plan for the SHP (LGL 1985a), which was intended to update, not supersede, information in the FERC application. Species accounts included vegetation resources, moose, caribou, Dall's sheep, brown bear, black bear, wolf, wolverine, lynx, coyote, red fox, beaver, muskrat, river otter, marten, mink, weasels, small mammals, waterbirds, bald eagle, golden eagle, gyrfalcon, peregrine falcon, other raptors and ravens, and terrestrial birds. Potential impact mechanisms were discussed individually and were rated as "important" or "not important" for the various species. Possible mitigation strategies—structured according to CEQ's NEPA sequence (40 CFR 1508.20) of avoidance, minimization, rectification, reduction, and compensation—were described for each important impact mechanism. Mitigation options were divided into discussions of engineering options, habitat compensation through land management, and nesting or other habitat enhancement for raptors and other birds.

Numerous changes have occurred in the biological sciences in the three decades since the original SHP study program was conducted, including revisions in taxonomy and nomenclature, changes in conservation status and population sizes, and advances in survey methods, research techniques, and data analysis. Among the most notable advances are improved radio-telemetry equipment and accuracy, the advent of geographical information systems (GIS) and associated spatial analytical techniques, and computer-intensive techniques of statistical analysis. We have made an effort to identify and discuss the implications of these advances for the identification of data gaps.

No species of terrestrial wildlife currently listed (endangered or threatened) or proposed for listing (candidates) under the Endangered Species Act (ESA; USFWS 2010) are known to occur in the Susitna River basin. Two subspecies of the Peregrine Falcon in Alaska (*Falco peregrinus tundrius* and *F. p. anatum*) were federally listed as endangered in 1970; *tundrius* was reclassified as threatened in 1984 and was delisted in 1991 and *anatum* was delisted in 1999 (USFWS 1999).

Increasing concerns about the status of a number of declining and vulnerable species in the 1980s and 1990s led to the creation of various lists of species generically referred to as species of conservation concern. Concerns had not yet been raised about the conservation status of most of these species during the early 1980s when the biological studies were conducted for the SHP, but increased awareness and knowledge of range-wide threats and population declines has accumulated in the intervening years. Currently, 55 of the bird species in the Susitna River basin are included on various lists of conservation and management concern, but only one mammal species (the Alaska tiny shrew, discussed later) is included. The single species of amphibian likely to occur in the middle and upper Susitna basin—the wood frog—is considered widespread and common in the state. For these reasons, the species of conservation and management concern are described under the Birds heading in this report.

Consistent with the management responsibilities and research emphases of state and federal agencies, this review is organized primarily by taxonomic groups and species of wildlife, and then by vegetation and wildlife habitats. This organization by study topic does not adequately portray, however, the complex ecological interrelationships occurring in riparian floodplains downstream from the WHP that may be affected by regulation of river flow; accordingly, those relationships are addressed in their own subsection (under Vegetation, Wetlands, and Wildlife Habitats). Due to the research emphasis of the original SHP wildlife studies and the volume of historical material produced, we discuss mammals first in this report before birds, rather than in the more traditional taxonomic order, and then discuss vegetation, wetlands, and wildlife habitats.

When discussing mammals, we follow the practice of the American Society of Mammalogists in not capitalizing English names, unless the species name includes a proper name. Conversely, we follow the American Ornithologists' Union convention of capitalizing the English names of bird species. Although they are included in the species lists because they have been recorded at least once in the project region, we do not dwell on extralimital (casual and accidental) species that do not occur regularly, such as the mountain goat (Aumiller and Ballard 1986) and Eastern Kingbird (Kessel et al. 1982).

MAMMALS

The list of mammals recorded to occur in the Susitna River basin comprises 38 species (Appendix A). The bulk of the wildlife studies conducted for the original SHP focused on mammals, especially big game and certain furbearers (moose, caribou, Dall's sheep, brown bear, black bear, wolf, and wolverine), because of their ecological importance and management concerns for human use, whether consumptive (subsistence and sport hunting) or nonconsumptive (wildlife viewing). These studies were conducted during 1980–1982 (Phase I) and 1983–1984 (Phase II) in a broad area around the proposed SHP, depending on the species. Detailed research reports were prepared for individual species, but summary progress reports on the big game studies (ADFG 1981, 1982, 1983, 1984a) provided overviews of the research results and data gaps from Phases I and II. Some problems noted by ADFG were attributed to the SHP reporting deadlines not being well-matched with research needs for data collection on long-lived, highly mobile animals. That limitation meant that only preliminary data could be presented for most of the species and definitive results could not be obtained for many of the topics addressed. No study efforts as comprehensive as the SHP program have been undertaken in the region since the mid-1980s, but ADFG has continued species-specific studies for research and management on selected species in various portions of the SHP study areas.

A number of information sources regarding the distribution and abundance of mammals are available for the region in various map atlas efforts (ADFG 1973, 1978, 1985a, 1985b) and related products from the Susitna River Basin Study (USDA 1985a, 1985b) and the Susitna Area Plan (e.g., the fish and wildlife element map atlas; ADFG 1984b), but the information in those maps has not been updated recently. In addition, the bulk of those mapping efforts are not available digitally, except for selected information on some species from the Alaska Habitat Management Guides (AHMG) project (ADFG 1985a, 1985b) that has been digitized for specific projects, but the map information itself has not been updated. The AHMG project produced useful summaries of wildlife species distribution and seasonal concentration areas through a statewide series of reference maps, which were based on literature review and the expert judgment of research biologists and area wildlife biologists (no local or traditional knowledge component was incorporated). That information formed the basis of much of the mapping still used today, even though the information is dated by 25–30 years.

MOOSE

Historical Studies

Baseline studies of moose in the Susitna River basin began several years before the formal SHP study program commenced in 1980. The moose studies for the SHP were divided into upstream and downstream (above and below Devils Canyon) components, with different investigators and objectives. The upstream study began with radio-collaring in 1976 and ended in January 1986 (Ballard and Whitman 1988, Ballard et al. 1991b). The downstream studies began in 1980 and continued through 1986 (Modafferi 1987), with monitoring of population dynamics continuing through 1991, using some of the animals collared for the SHP studies (Modafferi and Becker 1997).

Upstream

In the upper Susitna basin, Taylor and Ballard (1979) began radio-collaring moose in 1976–1977, and that work was continued later for the SHP (Ballard and Whitman 1988). Between 1976 and 1985, 463 moose, comprising 218 neonates, 61 calves aged 5–10 months, and 184 adults, were equipped with either visual collars or VHF radio-collars (Ballard and Whitman 1988). Twelve subpopulations were identified throughout the original study area, which included most tributaries of the Susitna River upstream of the mouth of Portage Creek (just below Devils Canyon). The study area was reduced in 1983, based on the home-ranges of radio-collared moose, to focus more closely on the proposed Devils Canyon and Watana impoundment zones.

Two population censuses were conducted in 1980 and 1983 to estimate population size and density, using an early version of a survey method employing stratified random sampling with sightability assessment (Gasaway et al. 1986). In November 1980, 4,500 moose were estimated in a 6,522-km^2 survey area (0.69 moose/km^2, or 1.8 moose/mi^2) and in 1983, 4,573 moose were estimated in a 7,856-km^2 survey area (0.60 moose/km^2, or 1.6 moose/mi^2) (Ballard and Whitman 1988). The highest density of moose within the original SHP study area occurred upstream of the proposed Watana dam site, between Watana Creek and Jay Creek at elevations of 650–850 m (2,133–2,789 ft) (Taylor and Ballard 1979).

All moose exhibited seasonal movements within their home ranges, but the magnitude varied substantially. Moose were classified as resident if seasonal ranges overlapped between summer and winter, or as migratory if they did not. Ballard et al. (1991b) reported that home-range sizes averaged 290 km^2 (112 mi^2) for resident moose and 505 km^2 (195 mi^2) for migratory moose. Distances between the summer and winter ranges of migratory animals ranged from 1 to 93 km (0.6–58 mi) (Ballard and Whitman 1988); the moose that moved the farthest were those that summered in the Clearwater Mountains north of the Denali Highway and wintered along the Susitna or Maclaren rivers. Three periods of major movements were identified: autumn and spring migrations and movements during the rut (breeding season). During rut in late September and early October, some moose made distinctive movements to upland areas not used at other times of the year. Most movements of radio-collared sedentary moose occurred from higher elevations in the summer to lower elevations in winter (Ballard and Taylor 1980). Fall migration began between late October and November and appeared to be correlated with the first heavy snowfall (>0.3 m, or 1 ft). Spring migration occurred more gradually, from mid-April through mid-July.

Ballard and Whitman (1988) documented 170 crossings of the Susitna River, by 59 (52%) of 113 radio-collared moose, in the two impoundment zones for the original SHP. Crossings occurred in all months of the year but were common during late winter, peaking in April, when moose occupied winter ranges at lower elevations. [Note: These numbers were minimal because of the nature of VHF radio-telemetry, which requires tracking from aircraft, unlike the more frequent monitoring that is now possible using satellite or GPS radio-telemetry.]

Vegetation types dominated by spruce and willow were used preferentially by moose. Taylor and Ballard (1979) recorded 70% of moose observations (n = 376) in spruce-dominated habitats (three of their nine habitat types were dominated by spruce) and reported that most locations where calves were first seen (n = 20) were in spruce-dominated habitats. Areas with relatively low browse biomass were used heavily by moose during winter, because more browse was available due to shallower snow cover (Ballard et al. 1991b). Moose used lower-elevation areas more often during severe winters and moose survival declined during severe winters (Ballard and Whitman 1988, Ballard et al. 1991b). The number and density of moose using the Watana impoundment zone varied widely among winters of moderate severity (1981–1983 and 1985), ranging from 42 to 580 (0.2 to 2.3 moose/km^2, or 0.4–6.0 moose/mi^2) (Ballard and Whitman 1988). Based on the carrying-capacity model developed for the SHP, Becker (1987) estimated that construction of the two SHP impoundments would reduce the carrying capacity of the study area by 405 moose during a moderate winter and 674 moose during a severe winter.

Radio-tracking of collared calves showed that predation, primarily by brown bears, was responsible for 83–86% of the mortality of moose calves (Ballard et al. 1981, Ballard and Whitman 1988), with 94% of the deaths occurring before July 19. Ballard et al. (1990) found that brown bears killed 46% of the calves in their study, black bears killed 9%, and wolves killed 7%. Elsewhere in interior Alaska (north of Tok), the highest predation rates on adult moose by brown bears were attributed to killing of cow moose during calving by male bears (Boertje et al. 1988). Bear densities and predation rates on moose calves were independent of moose density and were thought to be more related to factors such as availability of alternative foods. Relocation of brown bears from a 3,346-km^2 (1,292-mi^2) study area in southcentral Alaska lowered bear density by 60% and resulted in a significant ($p < 0.05$) increase in moose calf survival from birth to November (Ballard and Miller 1990).

Downstream

The lower Susitna River drainage has long been known as an important wintering area for moose. Modafferi (1987) summarized the downstream studies conducted for the SHP, which focused on identifying subpopulations and seasonal movements of moose using the Susitna River floodplain, as well as identifying candidate lands for mitigation of potential habitat loss caused by the SHP. VHF telemetry was used to study the movements and habitat use of 51 female and 18 male moose during April 1980–June 1985, and aerial censuses and other surveys were conducted repeatedly (6–11 times) during winter from December 1981 to December 1986. A population survey was conducted using stratified random sampling in March 1985.

Fourteen subpopulations were identified in the downstream study area from Devils Canyon downstream to Cook Inlet. Although some moose used the Susitna River floodplain year-round, most used the floodplain primarily in winter when snow levels restricted foraging in other habitats (Modafferi 1987). Some moose of each sex migrated up to 25 km (15 mi) from summer or fall ranges to winter on the floodplain, whereas the summer/fall ranges of other moose were smaller and coincided with floodplain winter range. The highest densities of moose occurred in open forest habitats, especially on high-relief islands near Cook Inlet where prevailing winds precluded accumulation of a deep snowpack. Overall, the greatest numbers of moose used low-relief floodplains where dynamic river flows maintained early succession plant communities that provided high-quality forage. On the late-winter survey in March 1985, 91% of the moose were found in 36% of the 353 sample units surveyed (4,252 mi^2, or 11,013 km^2); in those units, density ranged from 2 to 13 moose/mi^2 (0.8–5 moose/km^2).

Snow depth was the principal factor contributing to variation within and between years in moose counts on the middle and lower Susitna River floodplain. For the area downstream of Devils Canyon, maximum winter counts of moose on the floodplain ranged from 369 animals in a mild winter with shallow snow cover to 934 animals in a severe winter with deep snow cover (Modafferi 1987). In view of the generally low densities of predators in the lower Susitna valley at the time of their studies, Modafferi and Becker (1997) concluded that malnutrition was the principal cause of mortality in severe winters.

Additional data on moose using the western side of the lower Susitna drainage were collected by Didrickson and Taylor (1978), who identified three moose winter ranges: Kahiltna Glacier moraines, Peters Hills burn, and the Bunco–Home Lake area on the Tokositna River. The mean distance between winter and summer ranges was 13 km (8.1 mi) and the range was 3–19 km (1.9–11.8 mi) for radio-collared female moose.

Recent Studies

GMU 13 is an important area for moose hunting due to its accessibility and proximity to Anchorage and Fairbanks. Moose densities in GMU 13 were low in the early 1900s, increased in the 1940s, and peaked in the mid-1960s (Tobey and Schwanke 2008). Numbers then declined over the next 10 years, reaching a low in 1975 due to severe winters, increased predation, and large human harvests of both bulls and cows. The population increased during 1978–1987, averaging 5% annually, then declined 47% in the early 1990s and reached a low in 2001. After wolf control resumed in GMU 13 in 2003, moose numbers started to rebound (Tobey and Schwanke 2008). In a further effort to increase moose numbers, the hunting season was liberalized for brown bears, which in some areas may kill up to 50% of moose calves within the first 6 weeks of life (Tobey and Schwanke 2008).

The current management objective for the moose population of GMU 13 is 20,000–25,000 animals, while maintaining population ratios of at least 25–30 calves:100 cows, 25 bulls:100 cows, and 10 yearling bulls:100 cows in the fall (Tobey and Schwanke 2008). Trend counts in various parts of GMU 13 show an increasing population and an average of 0.5 moose/km^2 (1.3 moose/mi^2) among trend count areas (specific areas counted as a metric of moose population trends). In fall 2007, ratios of 32 bulls:100 cows and 22 calves:100 cows were recorded (Tobey and Schwanke 2008). The most recent density estimates for GMUs 13, 14, and 16 were in the range of 0.19–0.58 moose/km^2 (0.5–1.5 moose/mi^2; Table 1; Harper 2008).

Table 1. Recent estimates of moose densities and populations among game management units (GMUs) in and near the Susitna River basin. Population densities from trend counts may not be representative of the entire GMU.

GMU	Area (km²)	Population Estimate	Population Density (moose/km²)	Survey Type	Year
13A	11,512	–	0.50	Trend count	2007
13B	10,127	–	0.58	Trend count	2007
13C	5,343	–	0.58	Trend count	2007
13D	14,898	–	0.19	Trend count	2007
13E	18,669	–	0.31	Trend count	2007
14B	5,573	1,413	0.25	GSPE	2005
16A	4,791	1,619	0.34	GSPE	2005

Source: Harper (2008).

The highest moose densities in GMU 13 tend to occur on the southern slopes of the Alaska Range (Subunits 13B and 13C) and in the eastern Talkeetna Mountains (Subunit 13A). The lowest densities occur in the Lake Louise flats (Subunit 13D). Moose typically are found in subalpine habitats during the fall rut and post-rutting period, then move to lower elevations as snow depth increases. Earlier movements may occur where wolf densities have been reduced in riparian areas at lower elevations. Known wintering areas in GMU 13 include the southern Alphabet Hills, the upper Susitna River, the eastern foothills of the Talkeetna Mountains, the Tolsona Creek burn, and the Copper River floodplain in the eastern part of the unit.

Winter survival of moose is strongly related to snow depth, with mortality increasing markedly when snow depth exceeds 0.75 m (30 in.) (Tobey and Schwanke 2008). Calves are most severely affected, followed by yearlings, adult bulls, and cows. Deep snow also results in lower survival of calves the following spring. Moose mortality during severe winters does not appear to be density-dependent.

The most detailed study of moose in GMU 13 after the SHP ended was conducted by Testa (2001) during 1994–2000 in a 4,200-km^2 (1,622-mi^2) Nelchina study area, extending from Lake

Louise and the Tyone River on the east to the Kosina River on the west, and from the Glenn Highway on the south to the Susitna River on the north, and including trend-count areas 13 and 14 (which also were surveyed by Ballard and Whitman 1998). Testa examined the ecological constraints on moose population dynamics by studying population size, growth, winter habitat use, and effects of wolf and bear predation, resulting in a number of publications (Testa and Adams 1998; Testa et al. 2000a, 2000b; Testa 2004a, 2004b). Testa (2001) also estimated the predator populations in that study area, surveying brown bears in a 2,150-km^2 (830-mi^2) portion of GMU 13A (northern part of the Nelchina study area) using the CMR (capture–mark–resight) technique developed during the SHP studies (Miller et al. 1997), and estimating wolf population density from aerial surveys of tracks using the method developed by Becker et al. (1998).

Moose survey methods have advanced since the original SHP studies. The population survey for the SHP used an early version of the stratified random sampling approach developed by Gasaway et al. (1986), in which geographically defined survey units were searched at a standard intensity and a subset was searched intensively to derive a sightability correction factor for use in estimating how many moose were missed by the survey. The current approach favored by ADFG since 1997 is the Geospatial Population Estimator (GSPE; Kellie and DeLong 2006), which combines stratification with GIS-based geospatial analytical techniques to overcome problems stemming from using random sampling to examine spatially correlated distributions. The GSPE technique uses a grid of standard-sized sample units (2 minutes of longitude by 5 minutes of latitude) and can be applied to analysis areas as small as 777 km^2 (300 mi^2). A sightability correction factor can be incorporated to estimate the true density of moose in the study area.

CARIBOU

Historical Studies

Caribou herds in Alaska generally are delineated on the basis of their fidelity to calving grounds, following the herd concept proposed by Skoog (1968). Caribou that occur in the upper Susitna River basin belong primarily to the Nelchina Herd. A map of the historical range of the Nelchina Herd (from Hemming 1971) was reprinted by LGL (1985a: Figure 2.3-1) for the SHP studies. Pitcher (1982: Table 1, Figure 4) described annual and seasonal distribution information among various geographic areas of the herd range that originally were delineated by Skoog (1968).

Since the first herd-size estimates became available in the late 1940s, the Nelchina Herd peaked at ~70,000 caribou in the early 1960s, then declined precipitously to 7,000–10,000 by the early 1970s. Van Ballenberghe (1985) argued that the population decline in the 1960s was caused by overharvest and snow conditions, whereas Bergerud and Ballard (1985) argued it resulted mainly from wolf predation. The cause of the decline was debated further by Van Ballenberghe (1989) and Bergerud and Ballard (1989). A combination of those factors was the most likely explanation for the decline (Pitcher 1987).

At the time of the original SHP studies, the herd had increased to 18,713 by 1980 (Pitcher 1982) and 27,528 by 1985 (Pitcher 1987). It grew steadily to ~50,000 animals by 1995, then declined and has remained fairly stable, in the range of 30,000–35,000 caribou, since the mid-1990s (Figure 3).

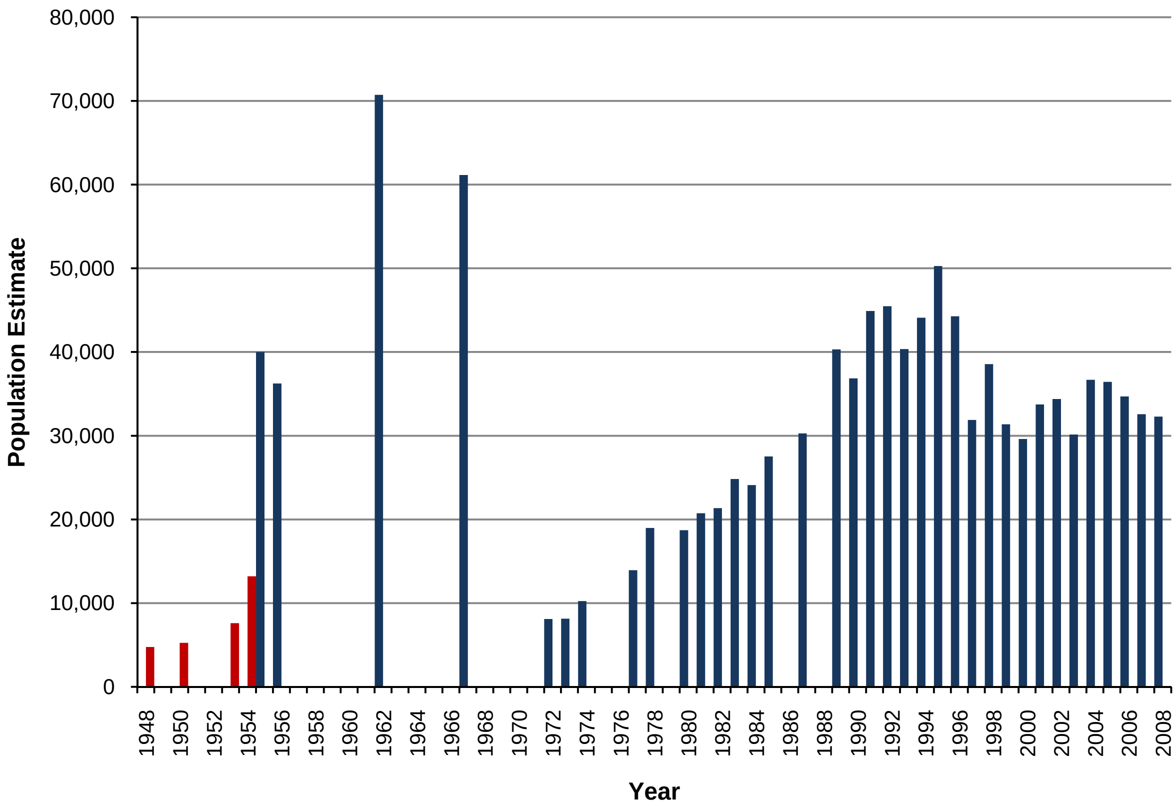


Figure 3. Estimated population size of the Nelchina Caribou Herd, 1948–2008.
Estimates before 1955 (red bars) likely underestimated the true herd size, judging from the 1955 and 1956 estimates. Sources: Watson and Scott 1956; Siniff and Skoog 1964,; Skoog 1968; Hemming and Glenn 1968; Bos 1973, 1974; Davis 1978; Pitcher 1982, 1987; Tobey 1993, 2001, 2005; Tobey and Kelleyhouse 2007a; Tobey and Schwanke 2009.

The caribou study conducted by ADFG for the SHP began in April 1980 and ended in October 1985, culminating in the summary report by Pitcher (1987). The study objectives were to determine the population status of the Nelchina Herd, delineate subherds, and investigate range use, movement patterns, migration routes, and timing, and to predict project impacts and recommend mitigation strategies. VHF radio-telemetry was the principal method of study, tracking 85 collared females for various periods of time (1–63 months, including 60 females that were monitored for two or more calving seasons), supplemented by photocensuses and population composition counts.

In addition to the main herd, three resident subherds were identified in specific portions of the herd range, based on radio-tracking. About 400 caribou were estimated to reside year-round in the headwaters of the Talkeetna River south of the SHP impoundment zones. Nearer the Susitna River, the Chunilna Hills had a resident group of about 250 caribou, and about 1,500 caribou used the upper Susitna, Nenana, and Chulitna river drainages year-round. Two additional subherds were suspected to occur in the western Talkeetna Mountains and in the Clearwater Mountains along the southern slopes of the Alaska Range.

The SHP project area is located at the western end of the Nelchina Herd's annual range. Winter range use showed the greatest variation among seasons. Winter distribution encompassed a large area east of the Talkeetna Mountains across the Lake Louise flats to the Wrangell Mountains, but did not include areas of historical winter use in the Talkeetnas and north of the Watana impoundment zone. The core calving area included the drainages of the Oshetna and Black rivers and Kosina Creek. The average elevation of females located during calving was 1,141 m (3,742 ft). Primary summer range for females was on the northern and eastern slopes of the Talkeetna Mountains. During rut in October, caribou were spread from the Talkeetna Mountains east to the foothills of the Wrangell Mountains. Spruce forests were used primarily during rut and winter. During spring, calving, and summer, males tended to use habitats at lower elevations and females used highland tundra–herbaceous habitats.

Spring migration to calving grounds in the eastern Talkeetna Mountains sometimes crossed the upper portion of the Watana impoundment zone. Historical records indicated that the reservoir would intersect a major migratory route used by pregnant females moving to calving grounds during late April and May, and by females and calves moving from calving grounds to summer range during late June and July (Pitcher 1982). Crossings generally were infrequent but, during spring migration in 1984, 50% of female caribou in the main Nelchina Herd crossed the Susitna River from north to south within the Watana impoundment zone (LGL 1985a). Skoog (1968) considered the geographic area in which the Watana impoundment zone was located to be among the most important year-round areas for the herd. Habitat loss was not considered to be an important concern, as only a relatively small area of apparently low-quality habitat would be inundated by the reservoirs (Pitcher 1982). The area of the Devils Canyon impoundment zone was used little by caribou, but the proposed northern access road from the Denali Highway would have traversed historical summer and winter range.

Recent Studies

Since the late 1990s, the size of the Nelchina Herd has remained near ADFG's population management objective of 35,000–40,000 animals in fall; the most recent herd size estimates were 32,569 in fall 2007 and 32,288 in fall 2008 (Tobey and Schwanke 2009). Because of its proximity and accessibility to residents of Fairbanks and Anchorage, the Nelchina Herd has long been an important resource for hunters. The management goal is to provide for an annual harvest of 3,000–6,000 caribou; actual annual harvests per regulatory year (July 1–June 30) were lower, estimated at 1,087–3,090 animals from 2003/2004 through 2007/2008 (Tobey and Schwanke 2009). Since 1977, Nelchina caribou have been hunted by permit only, and since 1990 almost all permits have been issued for state and federal subsistence hunts.

ADFG maintains an annual sample of 40–60 radio-collared animals in the herd to track seasonal distribution, movements, and productivity (Tobey and Schwanke 2009). The telemetry dataset for the Nelchina Herd consists almost entirely of VHF radio-collars, but 20 GPS collars were deployed on Nelchina females during 1999–2003 (B. Dale, ADFG, pers. comm.). Recent caribou management reports have not discussed the subherds that Pitcher (1987) described during the SHP studies, so the current status of those groups is not clear. Some of the GPS collars mentioned above were deployed in the area north of the Susitna in the area previously occupied by the Nenana–Susitna subherd, and indications are that a subherd still occupies the upper Susitna drainage.

The situation is complicated by the fact that caribou from the adjacent Delta Herd to the north have begun moving into the Nelchina Herd range in recent years. During 2006–2008, radio-telemetry revealed that some Delta caribou crossed from the north into the upper Susitna drainage along the Denali Highway as far as Butte Lake (Seaton 2009), mixing with Nelchina Herd animals. As many as 15% of the females from the Delta Herd may calve south of the Alaska Range (west of the Parks Highway) and some Delta Herd animals now spend most of the summer in GMU 13, but thus far the herds have remained separate during censuses (B. Dale, ADFG, pers. comm.). Delta Herd animals remain north of the Susitna River and do not use the area of the proposed Watana reservoir, but they occur along the Denali Highway near the potential WHP access road route.

For as long as records have been kept on the herd, the calving grounds of the Nelchina Herd have been centered between the Little Nelchina River and Kosina Creek, south of the upper Susitna River and southeast of the proposed WHP. During summer and fall, Nelchina caribou disperse over a broad area extending from the Denali Highway near Butte Lake as far east as the Gulkana River (Tobey and Schwanke 2009). The winter distribution is more extensive, ranging farther from Cantwell and Broad Pass on the west, east through the Alphabet Hills and Mentasta Mountains, to the area around Tok and almost to the Alaska–Yukon border, in GMU 20E. Formerly, GMU 20E provided high biomass of winter forage (lichens) in old (>50 years) burns, but much of that area burned in 2004, reducing winter forage availability. Collins (2006) found that lichens took 50–60 years to recover from burns in the range of the Nelchina Herd. Caribou preferred stands with most abundant lichen and stands that were >50 years old.

Wolves, grizzly bears, and Golden Eagles prey on caribou in the study area. Predator management programs have reduced the number of wolves in the range of the Nelchina herd since 2001, and calf recruitment to fall has increased (Tobey and Schwanke 2009).

DALL'S SHEEP

Historical Studies

During 1981–1983, ADFG surveyed three areas of sheep habitat near the Watana and Devils Canyon dams proposed for the SHP: Mt. Watana (south of the Susitna River), Portage Creek–Tsusena Creek–Denali Highway (near the potential access corridor north of the Susitna River), and the Watana Creek Hills (nearest to the proposed Watana reservoir). The study employed aerial surveys in March and June and ground observations of sheep using mineral licks during

May–July in the study area. An objective of the study was to document the seasonal distribution of sheep in the Watana Creek Hills, the area west of the Denali Highway access corridor, and the Mt. Watana area. Aerial survey counts of sheep in the Watana Creek Hills during June–September in 10 years from 1967 through 1983 ranged from 130 to 220 animals, including 18–27% lambs (Tankersley 1984).

During the Phase I study, sheep were discovered using a mineral lick below alpine habitat on lower Jay Creek in the Watana Creek Hills, adjacent to the proposed Watana reservoir. Several licks were located along that creek, extending upstream 6.5 km (4 mi) above its confluence with the Susitna River. The individual study areas (Watana Creek Hills, access corridor, and Mt. Watana) and locations of mineral licks were depicted by Tankersley (1984: Figure 1).

Investigators quantified use of the lick areas by different sexes and ages of sheep, recorded the seasonal timing of lick use, and collected soil samples for chemical analysis. Results were compared with similar data collected at the East Fork lick, located along Watana Creek ~12 km (7.5 mi) north of the Jay Creek lick. A total of 21 sheep were color-marked near the licks and behavioral observations were recorded during daylight hours. Sheep used mineral licks primarily between mid-May and mid-June. A minimum of 46 different sheep were recorded using the Jay Creek licks. At least 31% of the sheep population observed in 1983 traveled 8 km (5 mi) or more to the Jay Creek lick. Sheep traveled to the area even though another, smaller lick with similar chemical characteristics was located in their alpine range.

The Jay Creek lick soil, which contained significantly elevated levels of sodium, was exposed in several areas, mostly between 670 and 732 m (2,200–2,400 ft) elevation. The maximum water surface elevations expected for the low Watana reservoir in the original SHP were 666 m (2,185 f t) during normal operation and up to 670 m (2,200 ft) during flood conditions. Sheep in the ADFG study spent approximately 14% of their time below 670 m (Tankersley 1984). The proposed reservoir would not have inundated any major licks, but erosion and ice shelves may have resulted in the loss of lower areas of the Jay Creek lick and associated resting areas, and inhibited travel along and across Jay Creek to well-used lick sites (Tankersley 1984).

Recent Studies

ADFG conducts periodic aerial surveys and compiles harvest reports for Dall's sheep in subunits 13A, 13E, 14A and 14B (Talkeetna Mountains and Chulitna–Watana Hills), but the Watana Creek Hills have received little attention since the original SHP studies ended. According to the most recent report available, surveys were conducted in the Watana Hills in 1999 and 2003, producing counts of 97 sheep (18% lambs) and 50 sheep (14% lambs), respectively (Peltier 2008); the survey dates were not listed. In the overall reporting region, the estimated sheep population has varied substantially through time: 2,500–3,000 in the mid-1970s; ~2,500 in the late 1980s; 2,000–2,500 in 1994 and 2,500–3,000 in 1999, followed by a steep decline to ~1,750 after the severe winter of 1999–2000 (Peltier 2008). The population subsequently increased from 2000 to 2003, but declined again during 2004–2007.

Lohuis (2010) noted that the sheep population in southcentral Alaska had declined since 1990. A 3-year study to identify factors limiting population growth of sheep began in 2009 in the central Chugach Mountains (southeast of the Talkeetna Mountains), examining population dynamics in relation to disease and weather factors (e.g., formation of ice layers) that adversely affect sheep.

Whitten (1997) conducted double-count surveys using a fixed-wing airplane and helicopter to quantify the sightability of sheep and evaluate the effects of different survey intensities on sheep counts, reporting that their helicopter surveys produced counts 33–38% higher than from fixed-wing surveys.

BROWN BEAR

Historical Studies

All previous studies of brown bears in relation to the SHP were conducted upstream of Devils Canyon; no downstream study was conducted for this species. Brown bears were studied from 1980 to 1985, during which time 97 bears were equipped with VHF radio-collars. Radio-tracking provided data on population size and density, seasonal movements, dispersal, demography (litter size, age at first reproduction, reproductive interval, cub survival), den locations, and rates of predation on moose calves. Key findings were summarized and potential impacts were discussed in the final report by Miller (1987), which, unless otherwise indicated, was the source of the following information.

The study area (also referred to as the "impoundment impact zone," which was larger than the area that would have been inundated) was defined empirically as the area in which brown bears would be affected by the proposed reservoirs. This area was estimated by delineating the home ranges of 53 radio-collared bears. The mean home-range size for males and females combined corresponded to a circular area 37.5 km (23.3 miles) in diameter. Therefore, it was assumed that brown bears would be affected by the project within a corridor extending 37.5 km on each side of the Susitna River, from Devils Canyon to the confluence with the Oshetna River. Maps of the impoundment impact zone for brown bears and of the capture locations used to determine the home ranges were provided by Miller (1987: Figures 4 and 2, respectively). [Note that the study areas for brown bears and black bears differed because of differences in habitat use and home-range sizes.]

Density estimates were obtained in a portion of the study area using radio-telemetry and a capture–mark–resighting technique (Miller 1987, Miller et al. 1997). Density was estimated at 27.9 bears/1,000 km^2 (386 mi^2), which was equivalent to a total of 327 bears in the area affected by both of the reservoirs proposed for the original SHP.

The most significant impact of the project on brown bears was expected to be loss of habitat due to flooding of the Watana reservoir. Approximately 12% of the relocations ($n = 1,720$) of radio-collared brown bears were in the area that would have been inundated by the Watana reservoir; bears used that area twice as frequently as expected both in the spring and for all months combined. This pattern of use was evident for males and most females, but not for females accompanied by cubs of the year (COY). Bears spent the highest proportion of time in the Watana impoundment zone during June, when they foraged on south-facing slopes for roots, new vegetation, and overwintered berries, and preyed on moose calves. Females with COY tended to stay at higher elevations, possibly to reduce the risk of predation on cubs by male brown bears. Few collared bears used the Devils Canyon area.

The loss of denning habitat for brown bears was expected to be minimal. No dens were found in the area that would have been inundated by either of the proposed SHP reservoirs. Den sites were found at elevations in the range of 613–1,625 m (2,010 to 5,330 ft), mostly above the planned water surface elevation of the Watana reservoir (~670 m [2,200 ft]). The lowest den was found near Devils Canyon, where the terrain was lower overall. Miller (1987) mapped approximate den locations and provided detailed descriptions of den sites and dates of entrance and emergence.

Important sources of food for brown bears in the Susitna study area were ungulates, salmon, and berries. Attention was focused heavily on predation rates of brown bears on moose calves (Miller 1987, Ballard and Miller 1990, Ballard et al. 1990). Brown bears preyed on moose calves from late May to early June, with predation rates declining substantially by mid-July (Ballard et al. 1990). In addition to moose calves, the Susitna bear population had access to salmon, which is unusual for brown bears in interior Alaska. Bears, especially males, moved to the Prairie Creek drainage, southwest of Stephan Lake (between the Devils Canyon and Watana dam sites), during July and early August to feed on spawning chinook salmon (LGL 1985a). Despite the availability of protein-rich animal foods, berry production appeared to be the major factor limiting brown bear productivity in the Susitna study area (LGL 1985a). Miller (1987) estimated berry abundance and canopy coverage within and above both proposed impoundment zones. Crowberries were most abundant in the impoundment zones, whereas blueberries and lowbush cranberries were distributed more evenly across the area. Horsetails (*Equisetum* spp.), an important spring food, were more abundant outside the impoundment zones, but some sites with abundant horsetails would have been inundated by the proposed reservoirs (Helm and Mayer 1985).

The SHP study included data on river crossings by bears to facilitate post-construction comparisons (Miller 1987). Brown bears frequently crossed rivers. Of 658 point locations for males, 14.9% were on the opposite side of the Susitna River from the preceding location, as were 9.1% of 1,668 locations for females. Home ranges of male bears were larger than those of females, and therefore were more likely to span the river. Miller (1987) cited Simpson (1986), who stated that grizzly bears in the vicinity of the Revelstoke Reservoir in British Columbia "would cross a river but not the reservoir." Also at Revelstoke, Bonar (1985) noted "the radio-collared bears [of both species] haven't crossed as often as they did before the water came up."

<u>Recent Studies</u>

The Alaska Department of Fish and Game periodically estimates brown bear density in various parts of GMU 13; since 1979, those estimates have ranged from 16 to 41 bears/1,000 km^2 (386 mi^2) (Tobey and Kelleyhouse 2007). Different survey methods were used at various times, however, complicating comparisons among years. Current surveys generally estimate bear population density using advanced line-transect methods (Becker and Quang 2009), whereas density estimates formerly were conducted using the capture–mark–resighting (CMR) technique developed during the SHP studies (Miller et al. 1997). Regardless of the method used, Subunits 13A and 13E appear to have some of the highest brown bear densities in interior and northern Alaska (Tobey and Kelleyhouse 2007). Population density in Subunit 13E (in which the WHP would be located) was estimated in 1979 and 1987 but with different techniques so they were not directly comparable. Density was estimated in 1985 (27.1 bears/1,000 km^2) and 1995 (40.8 bears/1,000 km^2) using the CMR techniques, indicating that the population was increasing during that period. In 2000, 2001, and 2003, line-transect surveys were completed in portions of Subunit 13E, producing a preliminary estimate of 32.2 bears/1,000 km^2.

GMU 13 has been designated by ADFG for intensive management, so reducing the bear population is a management priority to boost the survival rates of moose and caribou for human consumption. Population reduction was sought mainly through liberalized bear hunting regulations involving longer seasons and higher bag limits (one bear per hunter per year vs. one bear every 4 years previously), increasing the mean annual harvest of brown bears from 61 animals during 1975–1978 to 139 animals during 2005–2008 (Miller et al. 2011). Although final results are not yet available, preliminary results comparing a survey conducted recently using the CMR technique in Subunit 13A West with previous CMR survey results suggests that the brown bear population in that area may have declined approximately 20% after two decades of higher harvests (B. Dale, ADFG, pers. comm.).

Belant studied brown and black bears in southcentral Alaska in the western Susitna basin (south of the Alaska Range between the Yentna and Chulitna rivers) during 1998–2000 using GPS telemetry, producing useful insights into sampling methods and the ecological relationships between the two species. Belant and Follmann (2002) compared home-range estimates using two different methods and noted that sampling only during daylight hours using VHF telemetry produced biased results of home-range and habitat use. Habitat use varied significantly within years and among seasons for different bears, and habitat use also differed between daytime and night-time periods. Brown bears foraged heavily at salmon spawning streams and salmon consistently composed a major portion of their diet, making an important contribution to body condition (Belant et al. 2006). Brown bears deterred access to salmon streams by black bears, which foraged heavily on berries due to avoidance of salmon streams occupied by brown bears (Belant et al 2006, 2009). The importance of salmon to brown bears specifically and to terrestrial ecosystems in general were discussed by Hilderbrand et al. (1999a, 1999b, 2004), who reviewed the role that spawning salmon play in transporting marine-derived nutrients into terrestrial ecosystems, where their consumption by bears and a variety of other wildlife species plays a crucial role in nutrient cycling.

BLACK BEAR

Historical Studies

Previous research on black bears for the SHP was conducted upstream from Devils Canyon, with the exception of a dietary study in the downstream area. Black bears were studied between 1980 and 1985; 110 bears were equipped with VHF radio-collars during that period. Collared bears were tracked to provide data on population size and density, seasonal movements, dispersal, demography (litter size, age at first reproduction, reproductive interval, cub survival), den locations, and rates of predation on moose calves. Key findings, as well as discussion of possible impacts, were summarized in the final report (Miller 1987).

The upstream study area ("impoundment impact zone") was defined as the area in which bears would be directly affected by the proposed reservoirs. This area was estimated by plotting the locations of all unmarked bears observed (n = 282 locations) and of 32 radio-collared bears (n = 2,273 locations) during 1980–1984 and then drawing a line around all points, excluding those considered to represent erratic movements (Miller 1987: Figure 7). Suitable habitat in the upstream study area was restricted primarily to the immediate vicinity of the Susitna River and its major tributaries. The downstream study area below Devils Canyon was based on home-range estimates for 22 radio-collared bears. In contrast to the upstream area, black bear habitat occurred over most of the downstream study area (Miller 1987: Figure 8). The black bear study area differed from the brown bear study area because of differences in habitat preferences and home-range sizes.

Estimates of population density were obtained in a portion of the study area using radiotelemetry and CMR techniques (described in Miller 1987 and Miller et al. 1997). Density was estimated at 89.7 bears/1,000 km² (386 mi²). That density produced an estimated total of 107 bears in the impoundment zone for both of the SHP reservoirs. Density estimates should be cautiously interpreted, however, because black bears are difficult to census for several reasons. First, black bears are difficult to see because they typically occur in dense vegetation; second, data from marked or radio-collared bears are difficult to convert to meaningful density estimates; and third, at the time of the original SHP studies, a standardized method for estimating black bear density had not yet been developed (LGL 1985a, Miller 1987).

The most significant impact of the SHP on black bears was expected to be loss of habitat, including den sites, due to flooding of the Watana reservoir; 42% of relocations (n = 1,305) of radio-collared black bears were in the area that would have been inundated (Miller 1987). Bears were particularly abundant in the impoundment zone during May and June, presumably foraging for overwintered berries and newly emerged plants such as horsetails, and preying on moose calves (the same spring food resources used by brown bears). Of 54 dens found in the vicinity of the Watana reservoir, 30 (55%) were in the area that would have been inundated. The rate of reuse of individual dens in the upstream area was high, suggesting that availability of den sites was limited. Miller (1987) concluded that, although transient black bears likely would continue to use the area, a resident population would not survive in the vicinity of the Watana reservoir. Black bears would have been affected less by the Devils Canyon reservoir, because most of the black bear habitat in that area was outside the impoundment zone. Of 30 dens found in the vicinity of the Devils Canyon reservoir, only one was in the area that would have been flooded. Miller (1987) provided a map of denning areas in the study area, as well as detailed descriptions of den sites and dates of entrance and emergence.

Black bears did not use the Prairie Creek drainage, likely because of exclusion by brown bears. Miller (1987) hypothesized that brown bears may have been displaced if human recreational use of that creek increased after SHP development. Because that stream provided good habitat for black bears and they are more tolerant of human activity than are brown bears, their use of the Prairie Creek area may have increased.

Although black bears in the upstream area occasionally ate moose calves, berries seemed to be their most important food source (LGL 1985a). Bears spent most of their time in forested areas along creek bottoms, but moved out into adjacent shrublands during late summer as they foraged for berries, particularly in the area between Tsusena and Deadman creeks (Miller 1987).

The potential for human–bear conflicts was higher in those areas because the shrublands were favored sites for camps, borrow areas, and permanent residences (Miller 1987). Berries were an important food for black bears in the downstream area as well. In contrast to the upstream area, movement data showed that black bears in the downstream area moved to riparian areas in July and August. Miller (1987) hypothesized that those black bears were eating salmon along river sloughs; however, he conducted a scat study in late August and concluded that black bears were foraging almost exclusively on devil's club rather than salmon.

The historical studies also included data on crossing behavior of radio-collared bears to facilitate post-construction comparisons (Miller 1987). Black bears made extensive seasonal movements up and down the river, remaining within the forested habitats along the river. Effects of the project on movements were difficult to predict, but crossings may have been inhibited, particularly by the large bay that would be created near the mouth of Watana Creek.

Recent Studies

Both the CMR survey technique developed by Miller et al. (1987) and the line-transect method of Becker and Quang (2009) are applicable to black bear populations as well as brown bears. No current estimates of population size were found for black bears in the upstream or downstream study areas along the Susitna River, however. The most recent report for GMU 13 (Tobey 2008) cited population estimates from the original SHP studies and the GMU 14 report (Peltier 2008) contained no population estimates.

No other research has been conducted on black bears in the vicinity of the WHP, but Belant conducted in-depth research on the interrelationships between black bears and brown bears in the western Susitna basin, using GPS telemetry (Belant and Follmann 2002; Belant etal. 2006, 2009), as discussed in the brown bear section above. Elsewhere in southcentral Alaska, studies of black bears were conducted on the Kenai Peninsula by Schwartz et al. (1991) and in the Anchorage area by Kleckner (2001).

WOLF

Historical Studies

The wolf study for the SHP was conducted in the Nelchina Basin and upper Susitna River basin between October 1981 and December 1983 (Ballard et al. 1982, 1983, 1984), as a continuation of regional research begun in 1975 (Ballard et al. 1981, Ballard et al. 1987). The SHP study was designed to investigate pack size, territory boundaries, location and use of den and rendezvous site, and feeding habits, based on tracking of wolves equipped with VHF radio-collars. A general map of the study area for wolves was included in Ballard et al. (1982: Figure 1). Ballard et al. (1983: Figure 1) showed pack territories in the upper Susitna River basin in 1981–1982. Similar maps of pack territories in 1982–1983 were originally included in Ballard et al. (1984), but were removed because the maps in earlier reports had been used by some individuals to concentrate their hunting efforts. Additional information on use of homesites (dens and rendezvous sites) was provided by Ballard and Dau (1983). The information summarized below is compiled from these reports.

Wolf packs used almost the entire upper Susitna basin, except for areas above 1,219 m (4,000 ft) elevation. Elevational use varied seasonally, probably in response to changes in relative availability of prey species. For example, the Watana pack depended heavily on moose as a source of food. Within the range of this pack , both moose and wolves occurred at the lowest elevations in February, then generally moved to higher elevations until October before moving downward again during winter.

During the study period, 13 different packs and a lone individual were documented using areas in or adjacent to the Devils Canyon and Watana impoundment zones. In any year, 5–6 wolf packs used the areas that would have been inundated by the SHP. Territory sizes of seven intensively monitored packs in 1982–1983 ranged from 329 to 1,559 km^2 (127–602 mi^2) and averaged 1,171 km^2 (452 mi^2).

Den and rendezvous sites usually were located on knolls or hillsides with sandy, frost-free soil and mixed, semi-open stands of spruce, aspen and willow (Ballard and Dau 1983). Wolves generally selected sites with south or east exposures and often used dens formerly occupied by red foxes. The mean elevation for all sites (den and rendezvous) was 777 m (2,550 ft) and the mean distance to water was 257 m (843 ft). The average distance between a den site and its nearest concurrently used neighbor was 45.3 km (28.1 mi). The authors noted that suitable sites for wolf dens appeared to be numerous in the area and that human encroachment was unlikely to result in a shortage of den sites as long as red fox densities remained similar.

The most important potential impact on wolves from the SHP was predicted to be reduced winter availability of primary prey species (moose and caribou) in the impoundment zones. In addition, habitat loss due to inundation and facilities development would have caused wolves to adjust territory boundaries, likely resulting in intraspecific strife.

<u>Recent Studies</u>

Most of GMU 13 (except Subunit 13D, south of the Glenn Highway), including the upper Susitna River basin, currently is managed by ADFG under a predator control program instituted in response to the state's intensive management law, passed in 1994. Wolves have been the target of a number of control programs over the decades, beginning before statehood. Wolves in the Nelchina Basin were reduced to an extremely low level by federal predator control in the late 1940s and early 1950s. After those control efforts ceased in 1959, the population recovered to 300–400 wolves by the mid-1960s and early 1970s, then declined to about 275 animals as harvest increased in the mid 1970s. After land-and-shoot hunting using airplanes was discontinued in 1988, the wolf population of GMU 13 increased rapidly, peaking at 12.4 wolves/1,000 km² (386 mi²) in 1999–2000, for an estimated population of 520 animals (Schwanke 2009). Land-and-shoot hunting was reinstated in January 2004 and the population subsequently declined to about 380 wolves by fall 2004 (Kelleyhouse 2006) and to 254 wolves (6.3 wolves/1,000 km²) by fall 2007 (Schwanke 2009). Since 2006, the number of wolves has been within the current management goal range of 135–165 wolves (3.3–4.1 wolves/1,000 km²) for the unit, after the end of the hunting and trapping seasons. Shooting wolves from aircraft has been permitted by ADFG since the winter of 2006–2007. The wolf population in GMU 13 has consistently shown the potential to increase by 60–120% between spring and fall, under general hunting and trapping regulations (Schwanke 2009).

In neighboring GMU 14, the wolf population was estimated at 100–130 animals in fall 2004 and 145–180 in fall 2007, well above the management objective of a minimum population of 55 wolves (Peltier 2006, 2009). None of GMU 14 is included in the state's predator control programs, however. Lice infestation has been a problem for wolves in Subunit 14B and adjacent Subunit 16A since at least fall 1998, possibly reducing wolf population size and harvest rates. On the western side of the Susitna River (downstream from about Willow), the western half of Subunit 16A and all of Subunit 16B are included in the state's current predator control program.

In other research in the region, Golden and Rinaldi (2008) investigated the spatial dynamics of wolves in relation to prey availability and human activity in the Nelchina Basin, including investigation of the use of snowmachine trails by wolves. The study ended early after the radio-collared study animals were killed as part of a predator control program, however. Rinaldi (2010) reported that the movements of five packs containing GPS-collared wolves were not influenced in consistent ways by snow conditions and prey distribution. Although they traveled faster on snowmachine trails and used trails more when snowmachine activity was low, wolves neither selected nor avoided linear features.

WOLVERINE

Historical Studies

ADFG conducted a mark–recapture study of wolverine in the upper Susitna River basin to investigate population density and distribution, habitat selection, home-range size, and seasonal movements (Gardner and Ballard 1982; Whitman and Ballard 1983, 1984; Whitman et al. 1986). A sample of 22 wolverines (13 males, 9 females) was captured and equipped with VHF radio-collars between April 1980 and April 1983. On average, collared animals were relocated every 12 days throughout the study, which ended in June 1983. Sufficient data to estimate home-range size were obtained for only four males and three females, however. The average annual home-range size was 535 km² (207 mi²) for males and 105 km² (41 mi²) for females.

Harvest records, track data, and incidental sightings also were used to help estimate distribution, population size, and food habits of wolverines in the Susitna basin. In addition to collared animals, the carcasses of 136 wolverines that had been harvested in or near the study area were examined. The sex ratio for the total of 158 wolverines captured or harvested was 50: 50 and approximately 30% of the harvested animals were juveniles.

Habitat use by wolverines varied among seasons, with respect to both elevation and vegetation types. The mean elevations at which wolverines were located were 1,043 m (3,422 ft) in July and 818 m (2,684 ft) in January (Whitman et al. 1986). Collared wolverines avoided tundra habitat s in winter and forested habitats in summer, probably because of seasonal changes in prey availability, and used other habitats in proportion to their availability. The spring and summer diet of wolverines consisted mainly of arctic ground squirrels, other small mammals, and ground-nesting birds, whereas caribou and moose carrion were important winter foods.

The most notable potential impact of the SHP on wolverine was considered to be permanent loss of winter habitat. A decrease in the regional moose population would have reduced the amount of carrion available to wolverines during winter. Whitman and Ballard (1983) estimated that at least 35 wolverines (45% of the estimated population in the Susitna basin) would have been affected to some degree by the reservoir. Improved access and a greater human presence in the region would have increased the potential for higher harvest rates of wolverines.

Recent Studies

Although no further research on wolverines has been conducted in the Susitna basin since the SHP study ended, new survey techniques have been developed to evaluate the distribution and density of wolverines over large areas of Alaska. Golden et al. (2007) used a sample-unit probability estimator (SUPE) to estimate wolverine density. With this method, the survey area is stratified based on predicted wolverine density and divided into 25-km² (9.7 mi²) sample units. Sample units are selected at random from each stratum and surveyed soon after a significant snowfall, until all wolverine tracks are located. Tracks are then followed in both directions to map the entire movement path since the last snowfall and determine the number of wolverines in the group. Data are analyzed using program SUPEPOP and formulas from Becker et al. (1998). Surveys sampling 65–70% of high-density sample units and 45–50% of medium and low density sample units should result in a density estimate with a coefficient of variation (CV) of <10%.

Magoun et al. (2007) and Gardner et al. (2010) used a different method to map wolverine distribution, based on presence or absence over larger survey areas. This technique does not provide density estimates, but rather provides estimates of the probability of occurrence over very large areas with a lower level of effort. The method uses occupancy models and hierarchical spatial models with Bayesian statistics. The survey area is divided into a grid of hexagonal sample units 100–1,000 km² (39–386 mi²) in size. From 0–4 transects are flown across each sample unit and wolverine tracks are recorded. If tracks are observed, no further transects are flown within that sample unit. Analysis takes into account the number of transects flown, environmental covariates, and numbers of tracks observed in adjacent sample units to calculate a probability of wolverine occurrence.

BEAVER

Historical Studies

Beavers are common in freshwater aquatic habitats bordered by woody shrub and forest vegetation in the Susitna River basin. Beavers were the only furbearers included in the Phase II studies for the SHP. The beaver was the species selected to predict downstream impacts of the SHP on furbearers, and was studied almost exclusively in the downstream study area (Gipson et al 1982, 1984; Woolington et al. 1984, 1985; Woolington 1986). Studies employed both aerial surveys to identify locations of lodges and caches and estimate population levels and overwinter survival, as well as boat surveys in summer to assess beaver sign. A general map showing beaver distribution in the SHP study area was presented by Gipson et al. (1982), and later Woolington (1986) included a map of colony locations.

Boat-based and fixed-wing surveys were conducted from Devils Canyon to Cook Inlet during summer 1980 (Gipson et al. 1982) and 1982 (Gipson et al. 1984). At locations where beaver sign was seen, the predominant vegetation types were classified and bank and water characteristics were described. The river was surveyed in three sections: Devils Canyon to Talkeetna (Section I), Talkeetna to Goose Creek (Section II), and Goose Creek to the Deshka River (Section III). In general, beaver sign increased substantially with distance downriver from Devils Canyon (Gipson et al. 1982, 1984). Side channels and sloughs were the habitat types used most often. Caches, lodges, and dens were found most often in habitats that had silty banks, willows, and poplars. Little to no sign of beaver activity was found in any section of the mainstem of the Susitna River during summer surveys (Gipson et al. 1984). In Section I, beaver numbers may be limited by a lack of lodge or bank den sites, and high water velocity also may prevent year-round occupation (Gipson et al. 1984).

Away from the Susitna River, beaver sign was found along slow-flowing sections of most tributaries, including Portage Creek, the Indian River (especially along a tributary of the Indian River flowing out of Chulitna Pass), streams along the alternative access-road route between Gold Creek and Devils Canyon, and Prairie Creek (Gipson et al. 1984).

During summer, beavers fed primarily on a variety of herbaceous plants, whereas during fall and winter they ate mostly willows, balsam popular, and some birch (Gipson et al. 1984). Alders typically were not eaten, but beavers used them preferentially for construction purposes.

Spring and fall counts of lodges and food caches were conducted only in Section I (Gipson et al. 1984; Woolington et al. 1984, 1985; Woolington 1986). Fall counts were conducted annually during 1982–1985 and spring counts were conducted in 1984 and 1985. The beaver population inhabiting the floodplain between Devils Canyon and Talkeetna was estimated by assuming that each cache represented five beavers. Between 1982 and 1985, that population was estimated at 70–220 beavers.

Overwinter survival of colonies during 1983–1984 was high due to a mild spring in 1984; 23 of 27 colonies survived. Two lodges along the main channel and one along an upland slough were partially destroyed by ice during breakup (Woolington et al. 1984). During 1984–1985, at least 23 of 45 colonies successfully overwintered (Woolington et al. 1985). All evidence of caches or lodges was destroyed during breakup at 10 sites, 7 of which were on the main channel. Flooding caused by ice jams destroyed lodges in two sloughs and one side channel. Survival of colonies was higher in sloughs than in side channels. Survival was lowest in the main channel. Overwinter survival estimates were considered essential to assess the effects of river flooding and ice-scour on beaver colonies (Woolington et al. 1985).

The number of fall food caches detected varied substantially (Woolington 1986). Observer experience and hydrologic regime were thought to have the greatest effect on the number of caches detected. Beavers build caches during fall as water levels drop and stabilize to winter flow levels. If surveys are conducted before water levels stabilize, cache construction may not yet be underway. It also was possible that the initiation date of cache construction varied by habitat (main channel, slough, side channel, etc.), although Woolington (1986) found little evidence to support that idea.

Habitat use varied among years, which may have been due to variability in August and September flows (Woolington 1986). When flow rate was high, the number of caches constructed along the main channel was low, but when flow rates were stable by August, then caches were distributed fairly evenly among the main channel, side sloughs, and upland sloughs.

Aerial surveys for beaver (and muskrat) were conducted in the upstream study area during spring and summer 1980 (Gipson et al. 1982). Colonies in the impoundment zones occurred mostly in lakes between 610 and 730 m (2,000 and 2,400 ft) elevation, relatively close to the planned water-surface level of the Watana reservoir. Colonies also were present in slow-moving sections of most of the larger tributaries, particularly Deadman Creek. No active beaver lodges or bank dens were found on the Susitna River upstream of Devils Canyon (Gipson et al. 1982), however.

Recent Studies

A large body of research demonstrates that the beaver is a keystone species that exerts profound ecological effects on hydrology, geomorphology, vegetation, nutrient cycling, the productivity of aquatic habitats, and the distribution and abundance of fishes and other aquatic organisms (Butler 1995, Collen and Gibson 2001, Müller–Schwarze and Sun 2003, Rosell et al. 2005). No recent literature on the beaver population in the Susitna River basin was found in our search. The furbearer reports produced by ADFG contain general abundance information obtained from trapper questionnaires, but not drainage-specific population data.

OTHER FURBEARERS

Other species of furbearers occurring in the Susitna basin include river otter, marten, mink, ermine, least weasel, red fox, coyote, lynx, and muskrat. A general map showing the distribution of furbearers in the SHP study area was presented by Gipson et al. (1982: Figure 1); Figure 2 in that report showed the aerial survey transects flown in the upstream study area during track surveys and checkpoints for sign of mink and otter, and Figure 3 showed the locations of red fox dens.

Historical Studies

Besides wolverine and beaver, studies of other furbearers focused primarily on marten, red fox, and muskrat. Observations of coyote, lynx , and weasels only were recorded incidentally to other work. Final results of the furbearer studies were presented in two of the original SHP reports (Gipson et al. 1982, 1984). A dissertation and a graduate thesis were produced at the University of Alaska Fairbanks, focusing on marten (Buskirk 1983) and red fox (Hobgood 1984), respectively. Although they do not contain additional data, they are useful references because each presents complete information on data and methods in a single document. Results of the marten study also were published in journals (Buskirk 1984, Buskirk and Macdonald 1984, Buskirk and McDonald 1989).

Marten

The population density of marten in the area that would have been inundated by both SHP reservoirs was estimated at 84.7 animals/100 km^2 (38.6 mi^2), based on aerial track surveys, estimates of home-range size, and habitat associations (Gipson et al. 1984). The total population of marten in both impoundment zones was estimated as a minimum of 218 animals, but aerial track surveys suggested that the population could be up to twice that number (Gipson et al. 1984). Nearly three times as many marten were estimated to inhabit the Watana impoundment zone as the Devils Canyon zone (Gipson et al. 1982). Marten occurred from Portage Creek to the Tyrone River, but their density was highest between Devil Creek and Vee Canyon (Gipson et al. 1982). Marten rarely crossed water that would require them to swim; the Susitna River and larger creeks formed home range boundaries (Gipson et al. 1982).

Marten were most common in coniferous and mixed forest below 1,000 m (3,281 ft) (Gipson et al. 1982). Habitat use in the study area was measured by the numbers of tracks observed during winter in different vegetation types (Gipson et al. 1984). Marten tracks occurred most frequently in forest and woodland cover types and less frequently in shrub cover types, in relation to the availability of those types in the survey area (Gipson et al. 1984). Winter resting sites typically were located in old or active squirrel nests (Gibson et al. 1984). Food habits were studied by analyzing marten scat and gastrointestinal tract contents (Gipson et al. 1984). Microtines and squirrels were the most important food classes during fall, winter, and spring. Too few marten scats were collected during summer to include in seasonal analyses.

Red Fox

Denning surveys showed that the most red fox dens by far occurred on the north side of the upstream reach of the Susitna River, despite extensive searches on the south side (Gipson et al. 1982). Typical den locations were 1,000–1,200 m (3,280–3,936 ft) elevation on south-facing slopes with sandy soils and a good view of the surrounding area; most dens were adjacent to lakes. The population density in the study area was estimated at 1 family/83 km^2 (32 mi^2; Gipson et al. 1982).

Winter surveys found most fox tracks at 516–1,129 m (1,692–3,704 ft) elevation and track density increased with distance upstream from Devils Canyon (Gipson et al. 1982). Track densities were similar on both sides of the river except for the area between Kosina Creek and the Tyone River, where tracks were more abundant on the south side of the river, most likely due to the presence of dispersing foxes. A major dispersal period occurred in mid-November (Gipson et al. 1984), when dispersers generally moved toward the upper reaches of the river, crossing from the north side to the south side. On the south side of the river, the habitat above Vee Canyon transitioned to marshy flats, which provided good foraging habitat for foxes (Gipson et al. 1982). Radiotelemetry data showed that dispersing foxes readily crossed the Susitna River (Gipson et al. 1982).

Muskrat

Aerial surveys for muskrat pushups were flown upstream from Gold Creek during spring 1980 (Gipson et al. 1982). Muskrat sign was seen most often in lakes on plateaus above the river valley, at 610–730 m (2,001–2,395 feet) elevation. Muskrat in the upstream area appeared to depend on fairly small, isolated areas of wetland habitats. Muskrat also were seen along slow-moving sections of creeks and at locations where creeks drained into larger streams, particularly near the Stephan Lake–Prairie Creek and Deadman Lake–Deadman Creek drainages.

Other Species

Other species, including river otter, mink, and weasels, were included in track surveys flown along the Susitna River upstream from Devils Canyon (Gipson et al. 1982). River otters were distributed fairly evenly throughout the upper Susitna drainage below 1,200 m (3,936 ft) elevation. During a November survey, a large number of otter tracks was seen on shelf ice along the Susitna River; those otters may have been feeding on grayling as the fish left tributaries to overwinter in the Susitna. Mink tracks were observed along all major tributaries below 1,200 m elevation; 50% of all mink tracks were in the upper reaches of the Watana impoundment zone. Most (87%) of the weasel tracks recorded were in the upper reaches of the study area near the Oshetna River; overall, 80% of weasel tracks were found in black spruce woodland or medium-height shrubland. Studies of furbearers in the downstream area were limited to a single August survey of beaver and muskrat along the Susitna River from Devils Canyon to Cook Inlet (Gipson et al. 1982).

Recent Studies

No detailed studies of furbearers in the Susitna River basin have been conducted since the original SHP studies ended. ADFG management reports for furbearers (e.g., Schwanke and Tobey 2007) do not include data on density, population estimates, or habitat preferences. Rather, they present results of trapper questionnaires as a way of assessing the general abundance of furbearer species and their importance to people. Marten are considered to be the most important furbearer species for trappers in GMU 13, but harvest data are unavailable because marten hides from that unit do not have to be sealed (Schwanke and Tobey 2007), unlike wolf, wolverine, beaver, lynx, and river otter.

In the decades since the SHP studies ended, substantial progress has been made in developing and refining survey methods for furbearers. Golden (2004) summarized work done over a number of years (2001–2004) to investigate furbearer species and refine population estimation techniques for Alaska: (1) estimating general abundance of furbearers using track surveys; (2) investigate habitat selection and develop a population model for coastal populations of river otters; (3) evaluate the accuracy of wolverine density estimation techniques; and (4) modify and enhance a lynx management model. Funding for those efforts was eliminated by 2005 due to ADFG budget cuts, however.

Other advances have focused on winter sampling methods using detection of tracks on aerial surveys. Becker (1991) developed a probability sampling method based on intercepting and following tracks of furbearers along survey transects following fresh snowfall, including a variation when radio-collared animals were available; he used these methods to estimate wolverine and lynx density in two study areas (1,870 and 285 km^2, respectively) in southcentral Alaska. Becker et al. (1998) developed a population estimation method using stratified network sampling involving detection of tracks after fresh snowfall and tracking to determine group size. More recently, a substantial amount of effort has been invested in noninvasive survey methods to estimate furbearer populations, such as combining genetic indices based on DNA from hair samples with capture–mark–recapture estimation methods (Mowat and Paetkau 2002, Long et al. 2008).

SMALL MAMMALS

Small mammal species found in the Susitna River basin include the snowshoe hare, porcupine, hoary marmot, arctic ground squirrel, red squirrel, pika, several species of voles, mice, and shrews, and the little brown bat (Appendix A). The meadow jumping mouse was not recorded during the original SHP studies but has since been documented from the "middle" Susitna River (MacDonald and Cook 2009). The occurrence of the northern flying squirrel in the region is unknown and in need of clarification (MacDonald and Cook 2009) but, if present, the species probably does not occur in the middle or upper reaches.

Historical Studies

The species composition, relative abundance, and habitat use of small mammals in the middle and upper Susitna River basin were studied in 1980 and 1981 along 49 trapline transects (using both snap-traps and pitfall traps) located in a variety of different habitat types (Kessel et al. 1982). The little brown bat and water shrew were not captured during the SHP study but were included in the list of species based on sight records and tracks, respectively (Kessel et al. 1982), and on specimen data collected in the surrounding region since the SHP studies ended. The study area for small mammal studies (Kessel et al. 1982: Figure 2) extended from Sherman (near Gold Creek) on the west to the mouth of the Maclaren River on the east and for approximately 16 km (10 miles) on each side of the Susitna River. No surveys of small mammals were conducted downstream of Sherman.

The most abundant and widespread small mammal species in the study area were the cinereus shrew, northern red-backed vole, and arctic ground squirrel. Red-backed voles and ground squirrels were thought to be the most important prey species for predators (both birds and mammals) in the upper Susitna River basin. Population levels of most shrews and voles varied considerably during the study period, but their relative abundance rankings remained unchanged. Patterns of habitat occupancy among these species indicated that shrews and red-backed voles were habitat generalists, exploiting a wide range of vegetation types, whereas meadow voles, tundra voles, singing voles, and lemmings were habitat specialists, using a narrower range of tundra and herbaceous vegetation types. Meadow voles and singing voles were the most selective, with the former preferring wet and mesic sedge–grass meadows and the latter preferring herbaceous shrub tundra. Habitat occupancy patterns were affected by changes in density and probably by competition among species.

Six species of small mammals occurring in the study area were not sampled directly by Kessel et al. (1982): arctic ground squirrel, hoary marmot, collared pika, red squirrel, porcupine, and snowshoe hare. Of those species, the arctic ground squirrel was the most abundant in the upstream study area and was considered to be ecologically important. Collared pikas and hoary marmots were locally common in alpine habitats, whereas red squirrels, snowshoe hares, and porcupines were fairly common to uncommon in forest and shrub habitats at lower elevations. Snowshoe hares, which constitute an important prey species for predators throughout interior Alaska, generally were restricted in the upper basin to areas east of Watana Creek. Localized high-density pockets of hares occurred in the vicinities of Jay Creek, Goose Creek, and the lower Oshetna River. Long-term information on hare abundance, provided by several local residents, suggested that the low numbers of hares in 1980 and 1981 were typical for the area, rather than representing a low phase in a population cycle.

Recent Studies

No recent reports on small mammal studies in the middle or upper Susitna basin were found in our search, although Cook and MacDonald (2003) alluded to 65 specimens of small mammals captured during 1,394 trap-nights of sampling in July–August 2002 near Trapper Creek in the lower Susitna basin. Other studies in surrounding regions included species inventories in Denali National Park and Preserve (Cook and MacDonald 2003) and on Fort Richardson near Anchorage (Peirce 2003), and long-term population monitoring (1992–2005) of three species of voles was conducted in Denali National Park and Preserve by Rexstad and Debevec (2006).

The most noteworthy change since completion of the original SHP studies is the recognition and description of the Alaska tiny shrew. This recently described species, the smallest mammal in North America, was discovered in the University of Alaska Museum collection by a visiting Russian mammalogist. It was first thought to be a Palearctic species (*Sorex minutissimus*) but, after further study, was described as a new species (*S. yukonicus*; Dokuchaev 1997). The earliest specimen was trapped in 1982 near the upper Susitna River during the original SHP study, but was identified at the time as a cinereus shrew. Dokuchaev (1997) listed only three locations where it had been recorded, but specimen records increased quickly as researchers looked for it elsewhere in the state. By the late 1990s, the species had been recorded over a broad area of interior, western, and northern Alaska, and inventory and monitoring efforts on national parklands in 2000 through 2003 added greatly to the knowledge of the species. By 2007, the total number collected statewide had increased to 38 specimens from at least 22 locations (Cook and MacDonald 2009). Early information on habitat affinities indicated it occurred primarily in riparian habitats, but as trapping efforts expanded, it also was captured in scrub habitats.

The Alaska Natural Heritage Program classifies the Alaska tiny shrew as "unrankable" globally (GU), presumably because little information was available, and as "vulnerable" in the state (S3; AKNHP 2011), probably due to restricted range and relatively few populations, and it was listed as a sensitive species by BLM (2010), presumably because of its S3 ranking by AKHNP. That ranking warrants further scrutiny, however, in view of the species' cryptic nature, the possibility of misidentification, the difficulty of capture, and its widespread distribution, as documented by inventory work in various parts of the state in the relatively brief time since the species was described (MacDonald and Cook 2009). Shrews generally are underrepresented in older studies that sampled with snap-traps and are much more reliably sampled using pitfall traps. Even so, the detectability of this shrew is low due to its small size and suspected ability to escape from metal-cone pitfall traps; plastic pitfalls are more effective at capturing it (G. Jarrell, pers. comm.).

Other changes since the original SHP studies have involved taxonomic and nomenclatural changes for various species. For example, the tundra shrew was split from the arctic shrew, which no longer is considered to occur in Alaska, and the names of several genera have changed (MacDonald and Cook 2009).

BIRDS

Numerous changes in avian taxonomy and nomenclature have occurred since the original SHP studies, mostly resulting from continuing studies of molecular genetics and corresponding changes in taxonomy, as reported periodically by the American Ornithologists' Union. The list of bird species in this report includes all those recorded during the original SHP studies, but reflects current taxonomy and nomenclature. Some species have been split and others have been added, however, resulting in a list of 142 species recorded or suspected to occur in the Susitna basin (Appendix B), of which 135 were recorded in the upper and middle basins during the original SHP studies in 1980–1981 (Kessel et al. 1982). That list was compiled during all types of surveys (summer and winter), including surveys of census plots for landbirds, lakes and ponds for waterbirds, and cliff habitats for raptors and ravens. The relative abundance of species was determined to be largely a function of habitat availability (Kessel et al. 1982: Tables 4–7), with Common Redpoll, Savannah Sparrow, White-crowned Sparrow, Lapland Longspur, and Tree Sparrow being the most abundant species. Thirteen bird species were recorded during winter surveys in 1981 (MacDonald and Cooper 1981) and 11 species in 1984–1985 (LGL 1986). In total, 16 species were seen in at least one winter survey. The most abundant resident birds were ptarmigan and redpolls in 1981 and Boreal Chickadee and Gray Jay in 1984–1985. After discussing species of conservation concern, the material below is divided among major groups: raptors (birds of prey); waterbirds (swans, geese, ducks, loons, grebes) and shorebirds (phalaropes, plovers, sandpipers); landbirds (songbirds or passerines).

SPECIES OF CONSERVATION AND MANAGEMENT CONCERN

All migratory species of birds are protected under the federal Migratory Bird Treaty Act (MBTA) and eagles also are protected under the federal Bald and Golden Eagle Protection Act. Both species of eagles occur in the Susitna River basin, so eagles and their nests will receive particular attention during the FERC licensing process. National guidance currently is being drafted by the USFWS for the preparation of eagle conservation plans for various types of development projects, including hydroelectric projects (J. Muir, USFWS, pers. comm.). The first such guidance was released in draft form for wind-energy development in January 2011; guidance for hydroelectric projects is still in preparation. The impetus for eagle conservation plans is increasing concerns about "take" of eagles elsewhere in the state and nation (e.g., at wind turbines), which has resulted in increased scrutiny of anthropogenic influences on eagle populations.

Other species of birds have been identified as being of conservation and management concern since the 1980s. The list of 55 bird species of conservation and management concern in the Susitna basin include 5 species of raptors, 26 species of waterbirds, 10 species of shorebirds, and 15 species of landbirds (Table 2). In compiling this list, we followed the recently issued (30 March 2011) memorandum of understanding (MOU) between FERC and the USFWS and incorporated lists of bird species maintained by the latter agency (USFWS 2008, 2009a) and by

Table 2. Bird species of conservation and management concern that are known or likely to occur in the Susitna River basin, Alaska.

English Name	USFWS BCC [1]	USFWS BMC [2]	ADFG [3]	BLM [4]	NAWCP [5]	NAWMP [6]	ASG (USSCP) [7]	BPIF (PIF) [8]
Greater White-fronted Goose (Tule)		■				■		
Snow Goose		■						
Brant		■				■		
Canada Goose		■				■		
Trumpeter Swan		■		■				
Tundra Swan		■						
Gadwall		■						
American Wigeon		■				■		
Mallard		■				■		
Blue-winged Teal		■				■		
Northern Shoveler		■						
Northern Pintail		■				■		
Green-winged Teal		■						
Canvasback		■				■		
Redhead		■				■		
Ring-necked Duck		■						
Greater Scaup		■						
Lesser Scaup		■				■		
Harlequin Duck		■						
Surf Scoter		■				■		
White-winged Scoter		■				■		
Black Scoter		■				■		
Long-tailed Duck		■				■		
Common Goldeneye		■				■		
White-tailed Ptarmigan								■
Red-throated Loon	■			■*	■			
Horned Grebe	■				■			

Table 2. Continued.

English Name	USFWS BCC [1]	USFWS BMC [2]	ADFG [3]	BLM [4]	NAWCP [5]	NAWMP [6]	ASG (USSCP) [7]	BPIF (PIF) [8]
Golden Eagle				■				
Gyrfalcon								■
Peregrine Falcon [9]	■		■					
American Golden-Plover							■	
Solitary Sandpiper	■	■					■	
Lesser Yellowlegs	■	■					■	
Upland Sandpiper	■	■					■	
Whimbrel	■	■					■	
unidentified turnstone [10]							■	
Surfbird							■	
Sanderling							■	
Wilson's Snipe		■						
Short-eared Owl				■				■
Boreal Owl								■
Black-backed Woodpecker								■
Olive-sided Flycatcher	■		■	■				■
Western Wood-Pewee								■
Northern Shrike								■
American Dipper								■
Gray-cheeked Thrush			■	■*				■
Varied Thrush								■
Bohemian Waxwing								■
Smith's Longspur	■							■
Blackpoll Warbler			■	■				■
Townsend's Warbler			■	■*				■
Golden-crowned Sparrow								■

Table 2. Continued.

English Name	USFWS BCC [1]	USFWS BMC [2]	ADFG [3]	BLM [4]	NAWCP [5]	NAWMP [6]	ASG (USSCP) [7]	BPIF (PIF) [8]
Rusty Blackbird	■			■				■
White-winged Crossbill								■

Species list derived from Kessel et al. (1982) and APA (1985: Appendices E5.3 and E6.3); see Appendix B.
[1] USFWS (2008) Birds of Conservation Concern.
[2] USFWS (2009a) Birds of Management Concern.
[3] ADFG (1998) Species of Special Concern.
[4] BLM (2010a) Sensitive Species; asterisk denotes Watch List Species (BLM 2010b).
[5] North American Waterbird Conservation Plan (Kushlan et al. 2002, 2006).
[6] North American Waterfowl Management Plan Committee (2004).
[7] Alaska Shorebird Group (2008).
[8] Boreal Partners in Flight Working Group (1999).
[9] Previously listed as threatened under the ESA, the American Peregrine Falcon (*Falco peregrinus anatum*) was delisted in August 1999.
[10] Species identity (Ruddy Turnstone, Black Turnstone) in the Susitna basin is unconfirmed, but both are on the ASG list.

specialist organizations that track conservation issues for various taxa (BPIFWG 1999; Kushlan et al. 2002, 2006; ASG 2008). We also consulted several lists maintained by other management agencies in Alaska that will be involved in the WHP review process (ADFG 1998, BLM 2010). It should be noted that not all of the species in Table 2 are of conservation concern; i.e., the USFWS list of species of management concern includes species that pose special challenges for various reasons. They are of concern because of population declines, small or restricted populations, dependence on restricted or vulnerable habitats, or overabundance to the point of causing ecological or economic damage.

RAPTORS

Historical Studies

The license application for the original SHP (Alaska Power Authority 1983) provided information on 53 nesting locations used by raptors and ravens in the middle and upper Susitna River basin. Those locations were discovered during raptor surveys conducted in 1974 (White 1974), 1980–1981 (Kessel et a1. 1982), and during field work on other avian species in the project area in 1982. Raptor surveys were not conducted downstream in the lower Susitna drainage, but some eagle nest locations were recorded during moose surveys (Modafferi 1987).

White (1974) found 10 active nests in the area he surveyed, including two Gyrfalcon, one Bald Eagle, and seven Common Raven nests, along with 14 inactive nests (eight ravens and three each of Golden Eagle and Bald Eagle). Active sites during the two years of study by Kessel et al. (1982) included four Common Raven, one to two Gyrfalcon, and one Northern Goshawk nest. Kessel et al. (1982) reported a linear nesting density for Bald Eagles of 0.04 nest/km (0.07 nests/mi) along the upper Susitna River. No Peregrine Falcons were found nesting in the SHP study area in the early 1980s (Kessel et al. 1982). In 1984, two previously known nesting locations of Golden Eagles were reevaluated and seven more eagle nests (five Golden Eagle and two Bald Eagle) were found (LGL 1984); five of the eagle nests were in outlying areas not previously surveyed and two nests were in previously surveyed areas along the river. A total of 33 eagle nests (23 Golden Eagle and 10 Bald Eagle) were located in the project area in the middle Susitna basin in 1984, but only four of the Golden Eagle nests and seven of the Bald Eagle nests were active that year (Roseneau 1984). Kessel et. al (1982) and Roseneau (1984) include text descriptions of historic nest locations, but no maps. Eagle nest locations are depicted on appendix maps in the amended FERC application (APA 1985), however.

Of the 12 Golden Eagle and 7 Bald Eagle nest sites near the Watana site, 5 and 3 nests, respectively, were expected to be inundated by the Watana impoundment (LGL 1984). Impacts and mitigation measures suggested in both LGL reports (LGL 1984, Roseneau 1984) include mitigation for avoidance of disturbance to raptors during nesting. Measures to prevent disturbance to nests of Bald Eagles and Golden Eagles (as well as Gyrfalcons and Peregrine Falcons) from the historic project plan were adapted from guidelines established by the ADFG and USFWS for the proposed Alaska Natural Gas Transportation System (Roseneau et al. 1981, APA 1983). The loss of some eagle nests to flooding of the Watana and Devils Canyon impoundments was thought to be unavoidable. Under the laws in effect at the time, that impact would have required mitigation by constructing artificial nesting structures and nest sites and/or creating additional nesting habitat. Hence, some of the historical literature reviewed focused on construction of artificial nest sites and structures for cliff and tree-nesting raptors (Grier 1969, Mathisen 1968, LGL 1984).

Recent Studies

The USFSW surveyed approximately 805 linear km (500 mi) of river within the Susitna drainage basin for nesting Bald Eagles in May 1988 (Parker 1988), locating 69 nests (49 active), of which 26 nests (20 active) were on the Susitna River. Linear density ranged from zero to 0.18 nests/km (0.29 nests/mi), with the highest density occurring on the Susitna River from Talkeetna downstream to the mouth. All nest trees were black cottonwoods, except for two white spruces. A nest tree was typically the largest in a stand of cottonwoods, and was located within 18 m of the river. It was estimated that 58 Bald Eagle nesting territories occurred on the Susitna River, with five additional territories farther away from the river in the Susitna Flats. The nest occupancy rate on that survey was 71%, much higher than the 22% reported by King (1980; cited in Parker 1988). The difference may be attributable to a difference in survey timing; the 1980 survey was conducted in mid-April, when some nests may not yet have been occupied.

Ritchie and Ambrose (1996) summarized information on nesting distribution, breeding ecology, and migration of Bald Eagles in interior Alaska, including portions of the Susitna River. Most nests along the Tanana River were within 100 m of a shoreline. Along the Tanana and the

Susitna rivers, most nest trees were balsam poplars, but white spruces were used commonly. Birds, especially waterfowl, were an important part of the diet of Bald Eagles, particularly in the spring. Salmon were the most important food in late summer and fall. Eagles typically began nesting activities in late April and most young fledged by late August. Recaptures of banded birds indicated that some Bald Eagles nesting in interior Alaska wintered at widespread locations in the continental U.S. The numbers of nest territories were estimated for several individual drainage areas, including the Susitna basin (150–250 nesting pairs). For interior Alaska overall, the number of nesting pairs was estimated at 525–725, with a fall population (including subadults and nonterritorial adults) of over 2,000 birds. The population of Bald Eagles appeared to be increasing, attributed to a combination of factors: (1) restrictions on organochlorine pesticides since 1973, (2) decreased persecution of eagles by humans in Alaska, (3) expanding eagle populations elsewhere in North America, and (4) warming climate.

Using aerial transect surveys, NRC (2010) surveyed Bald Eagle nest sites during 25–30 April 2010 in the Matanuska–Susitna Borough, including the Susitna River floodplain downstream to the mouth from the vicinity of Trapper Creek, the area between the Susitna River and Knik Arm, and the area around Wasilla and Palmer. A partial survey was flown along the middle reach of the Susitna River up to Indian River, locating seven nests. In all, 221 nest locations were recorded on that survey, of which approximately 101 were active nests.

Two previously undescribed eagle nests (one of each species) and a raven nest were found in a small survey area, including 4 km (2.5 mi) of the Susitna River, near the locations of proposed boreholes at a prospective material site south of the Watana dam site in late June 2011 (ABR 2011), suggesting that nest distribution may have expanded since the original SHP studies.

WATERBIRDS AND SHOREBIRDS

Historical Studies

Lakes, ponds, and wetlands were surveyed in 1980 and 1981 for waterfowl and shorebirds using ground-census methods during the breeding season and aerial surveys during migration (Kessel et al. 1982). Brood surveys were conducted on foot in July 1981 to document the presence of breeding waterbirds (adults with young). Aerial surveys were conducted by helicopter for migrating waterbirds (loons, grebes, and waterfowl) in spring 1981 and fall 1980 and 1981. Little survey effort was expended along the middle reach of the Susitna downstream to Talkeetna.

To quantify the use of waterbodies by migrating waterbirds and identify those used most heavily by various species and groups, a relative “Importance Value” was derived for each surveyed waterbody in each season, incorporating the number of species, the number of birds, and the density of birds on the waterbody in relation to the overall numbers and densities recorded on the surveys. Kessel et al. (1982) compared the use of waterbodies on the Susitna plateau with those in the upper Tanana River valley in east–central Alaska and concluded that the Susitna plateau, comprising mostly high-elevation subalpine habitats, was not a major migratory route for waterbirds.

Recent Studies

Annual population surveys of breeding waterfowl are conducted by USFWS throughout Alaska, and several transects within the Stratum 2–Nelchina survey area are located in the upper Susitna River basin (Mallek and Groves 2009a), east of the proposed Watana reservoir. The westernmost transect (oriented northeast–southwest) parallels the Oshetna River and the northeast–southwest stretch of the Susitna River just upriver from the Oshetna. Ten transects, sampling 135 km^2 (52 mi^2), extend from that western transect eastward across the Nelchina and Copper River basins to Chistochina and Indian River. Twelve species were recorded on surveys of that area in 2009; the most abundant taxa were scaups, Bufflehead, scoters, Mallard, and American Wigeon (Mallek and Groves 2009b).

A complete census of Trumpeter Swans on their breeding grounds in Alaska began in 1968 and was repeated at 5-year intervals between 1975 and 2005 (Conant et al. 2007). Together, two survey areas (Unit 3–Gulkana and Unit 5–Cook Inlet) include the entire Susitna River basin (Conant et al. 2007: Figure 1). The population of Trumpeter Swans summering in Alaska has increased since 1975 and breeding has expanded into peripheral habitat. In Unit 3–Gulkana, the count of swans was highest in 1995 (~4,500 adults and young), with slightly lower numbers in 2000 and 2005. In Unit 5–Cook Inlet, the count of swans was highest in 2005 (~2,600 adults and young), an increase of over 1,000 from the 2000 census.

LANDBIRDS

Historical Studies

Breeding landbirds and some shorebirds were studied using a modified territory-mapping technique on repeated visits to 12 census plots, each 10 ha (24.7 acres) in size, during 20 May–3 July 1981 (Kessel et al. 1982). Except for the alpine tundra site, each plot was established in a uniform area of one of the major woody habitats used by birds in the region (one plot per habitat type). The alpine tundra plot included several of the common habitats found at higher elevations in the study area. More than 60 habitat variables were measured on the plots for analysis of habitat selection and avian community data were summarized in terms of species composition, richness, diversity, and breeding density and biomass. Records were kept of all birds observed at field camps and during cross-country travel, and observations on the breeding chronology of different species were compiled.

MacDonald and Cooper (1981) surveyed wintering birds in the 12 census plots in February 1981. Later in the project, resident birds were censused three times, during early winter (29 November–1 December 1984), midwinter (23–25 January 1985), and late winter (27–29 March 1985), along two line transects in the Devils Canyon area and four transects in the Watana area (LGL 1986). Habitat types for each transect were determined on the ground and from aerial photographs. Densities (birds/km^2) were calculated as an index of abundance.

Recent Studies

No reports on breeding and resident birds in the middle and upper Susitna Basin since the mid-1980s were located. Several roadside routes on the Denali and Parks highways have been surveyed as part of the North American Breeding Bird Survey (http://www.pwrc.usgs.gov/bbs/) since the 1980s, providing supplemental information on regional species composition and abundance. Landbirds have been monitored in Denali National Park and Preserve over the last couple of decades, and several sites have been established there as part of the Monitoring Avian Productivity and Survivorship (MAPS) Program (http://www.birdpop.org/maps.htm). McIntyre (2006) reported changes in the abundance of selected species in Denali National Park and Preserve.

Survey methods for breeding landbirds have been refined and standardized further since the original SHP studies. The standard survey approach now is to use ground-based point-count surveys with distance sampling (generally within 400 m), with points randomized and allocated in proportion to habitat occurrence (Benson 2004) or in standard grids (Handel and Cady 2004). Point-count surveys with 10-minute observation periods at each point (Ralph et al. 1995) are the standard used by the Alaska Landbird Monitoring Survey (ALMS; http://alaska.usgs.gov/science/biology/bpif/monitor/alms.php#information) to enumerate breeding landbirds in remote, roadless terrain in Alaska (Handel and Cady 2004). That survey method also has been adopted for inventories of breeding shorebirds in Alaska (ASG 2008).

AMPHIBIANS

HISTORICAL STUDIES

Amphibians were not included in the original SHP environmental program studies.

RECENT STUDIES

Amphibians are of increasing conservation concern worldwide because of widespread population declines and extirpation of local populations (Collins and Storfer 2003, McCallum 2007). Of the eight species of amphibians that occur in the state of Alaska, only one inhabits interior Alaska—the wood frog, *Lithobates* (formerly *Rana*) *sylvatica*, which is the most common amphibian in Alaska (MacDonald 2003). The species occurs in suitable habitats throughout southern Alaska and in the interior north to the southern slopes of the Brooks Range. Wood frogs appear to be abundant throughout interior Alaska, but few quantitative data exist to evaluate their abundance. Wood frogs have been captured in Denali National Park and Preserve and are known to occur near Healy and in the lower Susitna drainage (Cook and MacDonald 2003; Anderson 2004; Gotthardt 2004, 2005; Hokit and Brown 2006). Recent studies of wood frogs in southcentral Alaska indicated that the species was "widespread and abundant" in developed areas along eastern Cook Inlet (Gotthardt 2004), although anecdotal reports from the Kenai Peninsula, Anchorage bowl, and the Talkeetna area suggested that wood frogs were no longer present at some historical breeding sites (Gotthardt 2005). Resource management agencies have devoted more attention to inventorying and monitoring wood frog populations due to population declines of amphibians elsewhere in North America and to reports of deformities in wood frogs elsewhere in Alaska (Anderson 2004).

Wood frogs occur in a wide variety of habitats during the year, moving into wetland areas to breed in the spring (beginning late April–early May) and then moving into adjacent wetland and upland habitats, usually within a few hundred yards of the breeding areas, during the summer (MacDonald 2003). Beaver ponds provide high-value habitat for wood frogs (Stevens et al. 2006). Egg-laying occurs in small ponds or lakes in wooded or open habitats; wood frogs reportedly avoid egg predation by fish by selecting waterbodies that are free of fish (Gotthardt 2005). Birds such as gulls prey on frogs during the breeding season. Wood frog breeding populations may vary by a factor of 10 and juvenile populations may vary by a factor of 100 among years (Berven 1990). Adult survival depends on rainfall, drought, and winter severity (Berven 1990, Anderson 2004). Wood frogs hibernate throughout the winter, entering hibernation as early as late August; the species is remarkable because of its ability to tolerate freezing during winter hibernation by producing chemicals that act as a natural "antifreeze" to prevent cell disruption (MacDonald 2003).

VEGETATION, WETLANDS, AND WILDLIFE HABITATS

HISTORICAL STUDIES

The vegetation and wildlife habitat studies conducted for the original SHP can be broken into four broad categories: (1) mapping of vegetation and wetlands; (2) studies of the availability and quality of browse for moose, which was identified as a primary candidate species for mitigation; (3) assessment of habitat values for a broad range of mammal and bird species; and (4) ecological relationships in riparian habitats downstream.

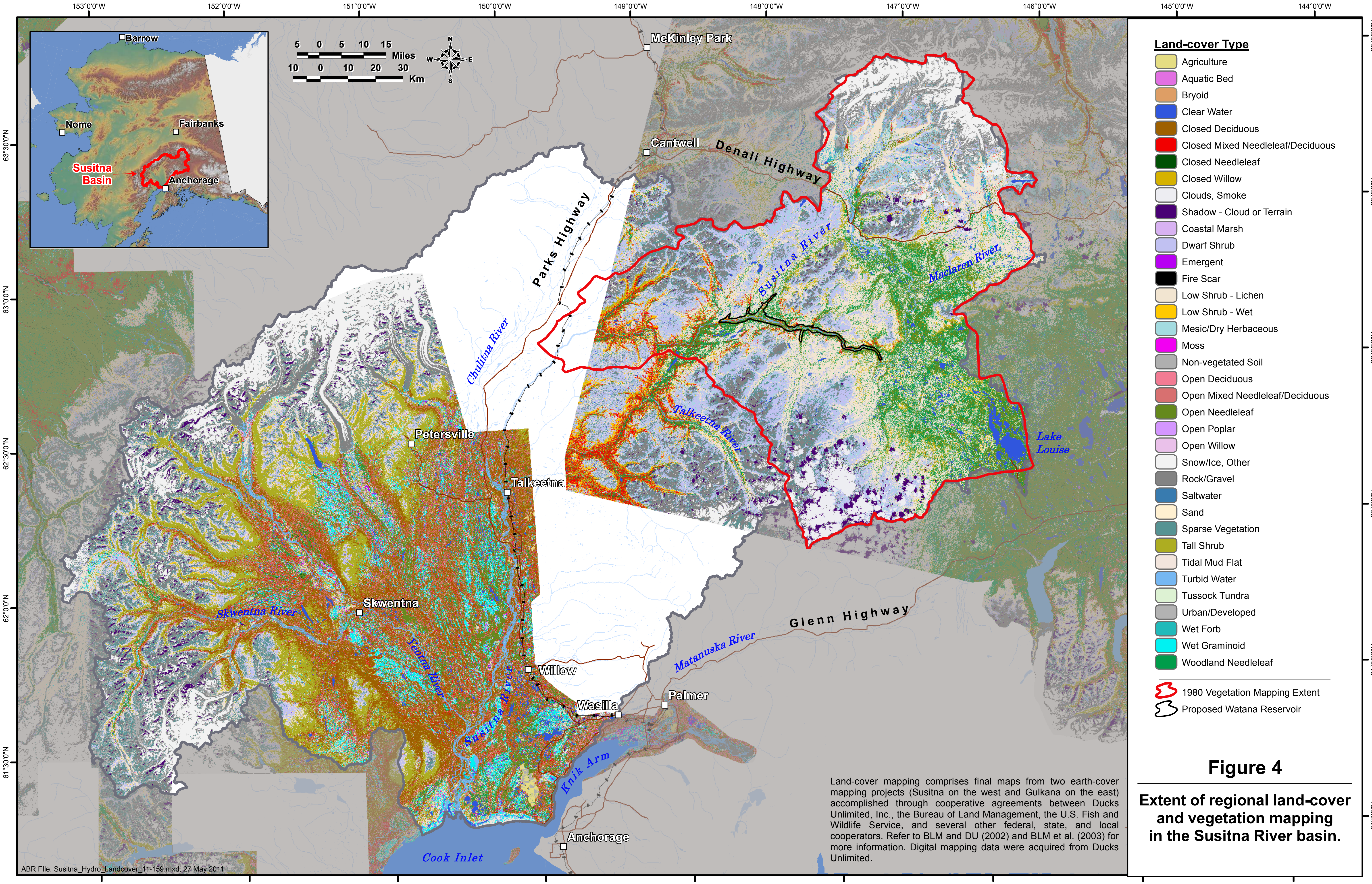
Mapping

Mapping for the SHP was conducted by several different groups of researchers. All maps were hand-drawn on mylar or acetate overlaid on aerial photos and topographic maps. The University of Alaska Agricultural Experiment Station (UAAES) conducted vegetation mapping during 1980–1982, based on field work conducted in 1980 (McKendrick et al. 1982). Mapping was based on field data and air-photo interpretation, and was primarily done to Level III (e.g., Willow Shrub) of the first version of the Alaska Vegetation Classification (AVC; Viereck and Dyrness 1980). Later, those data were incorporated into a separate mapping effort, for which field work was conducted in 1984 (Kreig and Associates 1987).

The vegetation mapping by McKendrick et al. (1982) covered a narrow corridor confined to the Susitna floodplain upstream from Talkeetna, then expanded outward to the basin level at Devils Canyon and upstream from there (Figure 4). The mapping boundary shown in Figure 4 was digitized by ABR from a scan of an original map copy included in APA (1983), but the corridor mapped downstream of Devils Canyon was not available, so is not depicted on the figure. The map scales were 1:24,000 for the areas that would have been impacted directly and 1:250,000 for the remainder of the basin. In addition, the area extending 16 km (10 mi) in all directions from the upper Susitna River between Gold Creek and the mouth of the Maclaren River was mapped at a scale of 1:63,360. A 1:24,000-scale map of "apparent wetlands" also was produced, as well as two other 1:63,360-scale maps for the proposed northern (Healy to Fairbanks) and southern (Willow to Cook Inlet) transmission-line corridors. The central transmission-line corridor was included on the 1:63,360-scale map of portions of the upper basin. These maps were included in the report by McKendrick et al. (1982).

The mapping done later by Ray A. Kreig and Associates (1987) covered parts of the upper and middle Susitna basin, from near the mouth of the Oshetna River (upstream of the Watana dam site) to just downstream of the Devils Canyon dam site. That mapping effort focused on habitats important to foraging ungulates, particularly moose. Mapping was done at 1:63,360-scale and incorporated previous mapping (McKendrick et al. 1982) and existing ground data and photography provided by ADFG, BLM, and the USFS, as well as newly obtained ground and aerial data. Vegetation types with high forage values (mainly shrub and forest types) were mapped to AVC Level IV. Each map polygon was assigned values for understory cover of willows, dwarf birch, and alder, and a limited ground-truthing survey was conducted. A database of attributes for every polygon was developed and exported in digital format to floppy disk, and those data were provided to ADFG.

A cooperative agreement between USFWS and the APA resulted in a preliminary wetlands map for the project area being produced, at a scale of 1:63,360, as part of the National Wetlands Inventory (NWI) (USFWS 1984). The NWI maps were based on the vegetation mapping done by McKendrick et al. (1982), with additional modification using stereoscopic photointerpretation. The original AVC vegetation classes were converted into wetlands classes using the classification scheme of Cowardin et al. (1979). Mapping was not finalized by the



Land-cover mapping comprises final maps from two earth-cover mapping projects (Susitna on the west and Gulkana on the east) accomplished through cooperative agreements between Ducks Unlimited, Inc., the Bureau of Land Management, the U.S. Fish and Wildlife Service, and several other federal, state, and local cooperators. Refer to BLM and DU (2002) and BLM et al. (2003) for more information. Digital mapping data were acquired from Ducks Unlimited.

Figure 4

Extent of regional land-cover and vegetation mapping in the Susitna River basin.

report publication date, but a preliminary table of wetland classes and acreages by project component was included.

Inventory of Moose Browse

A substantial amount of vegetation-related research for the original SHP focused on the availability and quality of forage for moose. The most important browse species for moose were shrubs, including willows, dwarf birch, and mountain cranberry (Steigers et al. 1983; Helm and Mayer 1985). The vegetation types with the highest availability of moose browse on the middle and lower Susitna River were late successional forests, including mature balsam poplar stands and mixed stands of white spruce and paper birch (UAAES and TES 1981; TES 1982; Steigers et al. 1983; UAFAFES 1985). Steigers et al. (1983) also found high availability of moose browse in dwarf birch–willow stands. In the upstream project area, late-successional forests occurred primarily in the floodplain of the Susitna River, where they would have been inundated by the proposed reservoirs.

Steigers et al (1983) conducted browse inventory and plant phenology studies in the middle Susitna River Basin, as well as an inventory and assessment of an area in the Alphabet Hills, east of the upper Susitna River, before prescribed burning by BLM and USFS. The browse inventory quantified shrub stem density, browse utilization, browse availability, and current annual growth biomass by vegetation class. Dwarf birch–willow vegetation was the most valuable type for moose browse. The hypothesis that moose focused on eating herbaceous plants during spring after snowmelt was not supported by the data. The study in the Alphabet Hills suggested that fire could increase the potential of forested vegetation classes as moose habitat and that shrubs were the primary food source of moose in these types.

Helm and Mayer (1985) studied plant phenology in areas inhabited by radio-collared moose in the proposed impoundment zones. Transects sampled along different elevations provided observations of shrub, forb, and graminoid phenology. Moose used the areas heavily during spring, before calving. Fecal analysis of moose pellets showed that moose in the area were eating mostly willows, mosses, resin birch, and mountain cranberry, with willows being the most important component; forbs and sedge were not significant forage plants for moose.

The majority of the area mapped in the Susitna basin for the SHP was covered by low mixed shrub, woodland and open black spruce stands, sedge–grass tundra, mat and cushion tundra, and birch shrub (UAAES and TES 1981). Less than 3% of the mapped area was occupied by deciduous or mixed coniferous–deciduous forests, which occurred on the Susitna River floodplain and would have been lost to inundation. Plant succession and available moose browse in the Susitna River floodplain would have been affected downstream of the dam sites due to altered water flow (UAFAFES 1985). To understand the potential effects of altered flow, the authors of that study examined successional patterns and abundance of vegetation types. They concluded that the most valuable successional stage for moose browse on the middle and lower Susitna River was late successional forests, including mature stands of balsam poplar and mixed stands of white spruce and paper birch, because they occupied a large proportion of the vegetated floodplain area downstream (48–72%) and had high browse diversity, even though the stem density of browse was lower than in earlier successional stages.

The primary SHP impact on moose upstream on the Susitna River would have been habitat loss. To evaluate that loss, a carrying-capacity model (Becker and Steigers 1987) was developed to assist in quantifying the impacts of the project. Nutritional carrying capacity was defined as the number of healthy individuals that can be maintained in a designated area for a specified period of time. One of the major inputs to the carrying-capacity model was the amount of browse available to moose during winter. The estimation of that parameter was the primary objective of study. A stratified two-stage sampling design was used to estimate the amount of willow, paper birch, and mountain cranberry browse in the primary impact zone, which was delineated using the movements of radio-collared moose. The study area was broken up into three subareas: the Devils Canyon population, the Watana impoundment population, and the remaining area. Resin birch was assumed to be a non-limiting browse item, due to its ubiquitous distribution. The impact of snow depth on browse availability was crudely adjusted for by calculating the amount of browse biomass above 0.5 m (20 in.) in height.

The amount of available willow browse was greater outside than inside either the Watana or Devils Canyon impoundment zones, whereas paper birch availability was lower outside of the impoundments than in either one. Mountain cranberry browse appeared to be greater in the Watana impoundment zone than in either the Devils Canyon impoundment zone or the areas outside of the impoundments. Based on their analysis, the construction of the Watana dam would have a far greater impact than would the construction of the Devils Canyon dam. The majority of browse was found outside of the impoundment zones. However, heavier browsing pressure occurred on willows inside the Watana impoundment zone than in areas outside of the impoundments, and browsing pressure decreased with increasing elevation in the non-impoundment areas. That difference suggested that not all of the willow browse found outside of the proposed impoundment zones was available to moose in the winter. Increasing snow depth with increasing elevation was one mechanism that would explain the different levels of browsing pressure.

<u>Wildlife Habitat Evaluation</u>

Several reports prepared in the early 1980s for the original SHP addressed the subject of wildlife habitat evaluation, as did a contemporary document developed for the larger Susitna River Basin Study. Wildlife habitats were evaluated using vegetation cover types mapped in the project area. As was discussed in the preceding section, the loss of moose habitat and its confounding effect on moose and their predators, in addition to the amount of habitat loss for other species, was been determined to be fairly significant. Two documents addressed the need for candidate lands to be used for mitigation of project-related habitat losses for moose and other wildlife species.

TES (1982) assessed habitat values for wildlife species in the SHP study area using a numerical ranking procedure. Habitats were derived from the vegetation types mapped within a 16-km band on each side of the Susitna River from Gold Creek upstream to the Maclaren River. Habitats were categorized and ranked by their overall value to wildlife; the highest rankings were accorded to those considered to have the most value for the most species. Numerous tables and appendices present the results of the rankings for each of the habitat types and species. The evaluations were based on field data for the project, literature review, and professional opinion of experts familiar with the area. The procedure for the wildlife habitat analysis consisted of assigning to each vegetation cover type (habitat) a value of 0–3, reflecting its importance as a life requisite for each of the wildlife species typically found in that cover type, for each of seven life-requisite categories for the species. In all, 21 habitats were ranked for 146 wildlife species. Open and closed mixed forests, wet sedge–grass, and woodland white spruce were the habitats receiving the highest rankings in the project area, and were considered to be of excellent value to wildlife. River and rock habitats were ranked the lowest and were considered of poor value to wildlife.

Harza–Ebasco (1984b) provided a review and synopsis of relevant moose-browse studies and provided recommendations for mitigating loss of moose habitat in the SHP study area, including tools such as prescribed burns and mechanical crushing of vegetation, with discussion of the cost effectiveness of the different approaches. Preliminary discussions on selection of candidate lands for moose habitat compensation for the original SHP were summarized by Sener (1984). Among other criteria, it was agreed that the total land area should be on the order of 405 km^2 (156 mi^2, or 100,000 acres) (although the final area could not be arrived at until the moose carrying-capacity and population models were refined); existing vegetation on compensation lands should have a high potential for producing moose browse following habitat-manipulation procedures such as crushing, clearing, or burning; and compensation lands should include a high proportion of relatively low-elevation, flat areas suitable as moose winter range (similar to the lands expected to be lost). Effects on some floodplain areas could be lessened by gradually transitioning water levels, lowering summer water levels and increasing winter levels, but it may not have been feasible to regulate flow for purposes other than power production.

Harza–Ebasco (1984c) updated and expanded material provided in the Susitna Area Plan and presented a preliminary listing of land areas being considered as candidate mitigation lands for wildlife impacted by the SHP. A map of lands proposed for mitigation of wildlife habitat losses for the SHP was included (Harza–Ebasco 1984c: Figure 1). That report described APA's evaluation to gather and review information on the suitability of candidate lands from both biological and institutional viewpoints. The report contains the preliminary listing of the land areas that were considered as candidate mitigation lands and their attributes (in a matrix format along with explanatory footnotes) and a map depicting their general locations. The lands were proposed to be managed in a manner that would benefit the wildlife resources inhabiting them on a seasonal or annual basis.

The Susitna River Basin Study (1985a) was a large collaborative effort among the USDA Soil Conservation Service, USDA Forest Service, State of Alaska, and USFWS to inventory resources in the Susitna River watershed. The study was intended to provide accurate information to ADNR (for the Susitna Area Plan) and the Mat-Su Borough for land-use planning and land sales. The information gathered was also intended to identify water and land resource problems, analyze the economic base and environmental setting, and suggest alternative plans for solving identified problems and improving the economy and environment. One of the reports generated for the study was a regional evaluation of wildlife habitats (USDA 1985b). The watershed was split into four subbasins for the study: Willow, Talkeetna, Beluga, and Upper Susitna (the latter subbasin covered most of the area of interest for the WHP). The data for the Willow subbasin was the most detailed, and data for the Upper Susitna subbasin were not as detailed as for the other subbasins. Most of the data presented in the report did not apply to the upstream project area, but did apply to the downstream area. The authors stated that the technical analyses discussed in the report applied only to the Talkeetna Mountains and lower Susitna River area and not the area of interest for the SHP. The report (USDA 1985b) provided results on habitat scarcity for the Upper Susitna basin, however.

Fish and wildlife modeling and mapping were done to varying degrees (USDA 1985b). The technical analyses consisted of collaborative work to model the fish and wildlife values of basin lands and to assist ADFG in creating fish and wildlife "element" maps that could be used to assess land-use alternatives. Habitats were evaluated in terms of their relative ability to provide food and cover seasonally to selected wildlife species, their relative ability to support a variety of wildlife species, and their relative abundance within the basin. High-value lands were broken into four "sensitivity/management" categories and recommended land use practices were outlined for each category. A wildlife species diversity model was applied to identify and map those vegetative communities (habitats) that were capable of supporting the highest diversity of wildlife species. The diversity component was based on habitat evaluation procedures developed by Konkel et al. (1981) for the Alaska Natural Gas Pipeline corridor, as well as on work by Gipson (1982) and Kessel et al. (1982) for the SHP studies. The vegetation cover types used by Konkel et al. (1981) were cross-correlated with cover types mapped in the Susitna Basin, as were wildlife species lists. A "habitat scarcity" model was developed to incorporate a regional perspective in the development of fish and wildlife element maps. Relative scarcity of different habitats was assessed by determining how much area each vegetation type covered and then comparing that with the area of subbasin that each type would cover if all types were equally abundant. After completing these different models, a "habitat synthesis" model was created to use computerized inventory data to develop fish and wildlife element maps.

The fish and wildlife element atlas (ADFG 1984b) consisted of maps, at scales of 1:63,360 or 1:250,000, outlining lands that biologists recommended be allocated and managed for fish and wildlife, with supplementary narratives describing the supply of, demand for, and economic contributions of study area fish and wildlife. The Upper Susitna subbasin had an element map at 1:63,360, as did the Talkeetna subbasin. The original maps were filed with ADNR in Anchorage. GIS databases (the earliest mention of GIS applications found for the Susitna basin) were created by the Environmental Research Systems Institute (ESRI, Redlands, CA); reports describing the databases were produced in 1982 for the Taklkeetna and Beluga subbasins and in 1983 for the Upper Susitna subbasin, but those reports were not examined for this analysis.

Downstream Riparian Ecology

One document from the original SHP studies directly addressed the question of downstream ecological effects involving vegetation and wildlife habitats — the riparian vegetation succession report prepared by the University of Alaska–Fairbanks Agricultural and Forestry Experiment Station (UAFAFES 1985), from which the material in this section is summarized. The purpose of that study was to provide an understanding of existing riparian dynamics and to assess the changes that might result from construction of the SHP.

If the project were constructed, water levels in summer would have been lower than under natural conditions. In winter, water levels would have been higher than normal, and ice formed at those higher levels may have encased vegetation for up to 4 months each winter at some locations. With the project in operation, fluctuations in flow throughout the year would have been greatly reduced. In the middle river (between the Oshetna and the Chulitna rivers), summer flooding events would have been fewer and less severe. No bedload sediments would have been transported from the upper river because they would be trapped in the reservoirs. Fine silts and clays would have continued to pass through the middle river, but would not be deposited. The riverbed likely would have developed an “armor” layer as fine sediments were scoured out and not replaced. Due to the more uniform flow, the channel may have become deeper and narrower. The upper 24–45 km (15–28 mi) of the middle river would no longer have winter ice cover. Downstream from there, spring melt likely would have been slower, with little or no ice jamming or associated flooding and scouring.

In the lower river, long-term aggradation would have been likely in the first few miles below the Chulitna River confluence, causing the Chulitna delta to expand farther toward the east bank of the Susitna River. A well-defined channel eventually would have developed through that delta due to the stabilized flows in the middle river. The magnitude of changes due to high-flow events would have decreased, although the difference would be less marked than in the middle river, because the lower river is affected by floods generated in the Chulitna and Talkeetna rivers. No major changes in ice dynamics were expected in the lower river.

Reduced seasonal fluctuation in water level potentially would have affected the establishment of poplar and willows in early successional habitats in the Susitna floodplain. Seeds of those species are dispersed during spring floods (the only time they are viable). Seedlings establish and grow during summer, after the water level recedes. Reduced flooding likely would limit seed dispersal onto suitable substrates, and low summer water levels may have affected seedling growth and survival negatively. Construction of the project may have affected succession at sites where vegetation was already established. Under natural conditions, succession frequently is "reset" by summer floods and winter ice jams. With those events reduced in frequency and severity during project operation, the relative abundance of vegetation at different successional stages may have been altered. Such alteration could affect forage availability for some wildlife species, such as moose, because browse abundance differs among successional stages.

RECENT STUDIES

Mapping

Relatively recent land-cover maps (BLM et al. 2002a, 2002b) covering parts of the Susitna River basin were produced for Ducks Unlimited, Inc., in cooperation with BLM and the U.S. Air Force, based on classification of satellite imagery. Two separate mapping efforts were conducted—one for the upper Susitna River drainage and Gulkana area (BLM et al. 2002a), which covers much of the SHP study area, and the other for the lower Susitna River drainage, Cook Inlet, and westward (BLM et al. 2002b)—but a sizable gap in map coverage occurs around the middle reach of the Susitna River (Figure 4). The vegetation classification system for both maps used AVC classes (Viereck et al. 1992), including a combination of Level III and Level IV. The classification does not differentiate among types of tall shrubs or distinguish low alder from low willow, both of which are key factors when evaluating habitat value for moose. Few of the field sites used to verify map accuracy were located in the WHP study area, so vegetation types may not be represented accurately. In addition, the map that covers most of the original SHP study area (BLM et al. 2002b) was based on a composite of three Landsat scenes from different years and different dates during the growing season, resulting in increased variability of spectral signatures across the scenes.

Another land-cover map of the entire Susitna basin is available through the National Land Cover Dataset (NLCD) (Stehman and Selkowitz 2010), which is based on classification of Landsat imagery. This mapping was part of a nationwide effort to create a unified land-cover map and is the first moderate-resolution (30-m pixel) classification covering Alaska in its entirety. The cover classes are very generalized (roughly equivalent to AVC Level II), however, and thus are of limited use for meaningful habitat analyses.

Paper maps of wetlands for parts of the middle and upper Susitna basin, including the areas that would have been affected by the original SHP, are available from the USFWS National Wetlands Inventory (NWI) program, but those data are not available in digital form. Digital versions of NWI maps are available from USFWS for parts of the middle basin and all of the lower basin.

Inventory of Moose Browse

A pertinent study of moose habitat use in the lower Susitna drainage was conducted by Collins and Helm (1997) in the early 1990s, in conjunction with a companion study of floodplain ecological succession (Helm and Collins 1997, described further below under Downstream Riparian Ecology). The investigators were two of the authors for the original SHP study of riparian succession, described above (UAFAFES 1985). Browse availability was the principal factor influencing winter habitat selection by moose, and early shrub and old balsam poplar (cottonwood) successional stages were most important to wintering moose. Browse availability depended on winter snow depth. Feltleaf willow (*Salix alaxensis*) was the most important browse species, with a utilization rate of 76% in a winter of average snow depth. Unvegetated sites, dry sloughs, and frozen river channels accumulated significantly less snow than other sites and were used preferentially by moose for access to foraging areas as snow cover deepened. The authors concluded that, unless flow of the Susitna River was affected by hydroelectric development, habitat enhancement for moose should focus on upland sites rather than on riparian habitats on the floodplain, because normal river flow rejuvenated early successional stages without human intervention.

Collins (2002) also studied moose forage use and plant secondary compounds in the Oshetna River and Tyone Creek drainages south of the upper Susitna River, in the Nelchina study area of Testa (2001, 2004a). Use of feltleaf willow was highest in winters with deep snow, when diamondleaf willow (*Salix pulchra*) plants were mostly buried by snow. Moose used dwarf birch possibly because lower levels of tannin provided more digestible protein. Moose had low reproductive rates even when winter browse availability was not limited, and browse did not appear to be limiting to the population until the protein-limiting effect of tannins was taken into account. Because of tannins in browse plants, moose in the study area may be experiencing severe nutritional limitation in winter.

Seaton (2002) developed a browse-survey protocol to compare the proportional removal of the current annual growth of selected forage species (willows, poplars, paper birch) between 0.5 and 3 m above ground by moose in the northern foothills of the Alaska Range and on the Tanana Flats. That protocol has been adapted for wider use throughout Alaska (Paragi et al. 2008). Seaton et al. (2011) compared browse use, measured with this method, with twinning rates of moose (a measure of nutritional condition) among eight study areas in interior Alaska. They found that the twinning rate (7–64%) was inversely correlated with proportional browse removal (9–43%) by moose, and recommended that proportional browse removal be used as a nutritional index for studies of moose and predator populations and for habitat manipulation in boreal forest. Recent work to evaluate moose range in interior Alaska has focused on combining the proportional browse removal method with landscape-level GIS analyses of snow depth and land cover (Paragi and Kellie 2011).

McArt et al. (2009) studied the seasonal progression of the nutritional value and digestibility of moose forage during three summers in Denali National Park and in the Nelchina Basin (in the foothills of the Talkeetna Mountains, south of the proposed Watana reservoir). They quantified nitrogen concentrations in leaves, tannin–protein precipitation capacity, and digestible protein in five primary forage species comprising 79% of the summer diet, and found 23% more digestible protein in Denali forage than in the Nelchina. Based on those results, a net-protein-intake model predicted that cow moose in Denali would experience positive protein balance an average of 17 days longer than Nelchina cows and that Denali cows would accumulate 18 kg more lean body mass over the summer. Tannins accounted for a large reduction in protein availability over the course of the summer.

Wildlife Habitat Evaluation

The habitat evaluations used in the Susitna Area Plan and Matanuska–Susitna Borough land-use planning efforts were derived from the original SHP and Susitna River Basin Study efforts (ADFG 1984b, USDA 1985b) and from the AHMG map atlases (ADFG 1985a, 1985b). Since then, no resource mapping efforts have been undertaken that are as comprehensive in coverage as those early efforts. Recent habitat evaluations are not available on a regional scale, but more localized assessments of wildlife habitat value have been conducted periodically for specific development projects elsewhere in southcentral Alaska, usually by relating habitat-use information across a range of species and habitat types. We found no recent evaluations that are applicable to the middle and upper Susitna basin, however.

Downstream Riparian Ecology

A number of recent studies provide background information regarding ecological effects on riparian floodplain habitats downstream from the proposed WHP. Helm and Collins (1997) examined the dynamics of vegetation succession on the Susitna floodplain at 29 sites located from Chase (above Talkeetna) downstream to the mouth of the Deshka River (near Willow). This paper was based on field work conducted in the early 1980s during the original SHP, with additional work conducted later in 1995, plus comparisons with historical aerial photos from 1951. The successional stages were described as Early Shrub (*Dryas*, juvenile poplar, willow, horsetail), Intermediate (alder, young poplar), and Late (old poplar, birch–spruce). The youngest stage of succession comprised four distinct communities based on substrate texture. The effects of a variety of factors—flooding, ice scour, wind, browsing by herbivores, and human activities such as logging—were assessed and a conceptual model of successional pathways was developed. The authors concluded that the major factors influencing vegetation succession were sedimentation and erosion from flooding and herbivory by wildlife. Vegetation establishment varied annually in relation to precipitation and flooding.

Stanford et al (2005) described the naturally shifting habitat mosaic of river ecosystems. Damming a river alters these patterns. Effects include the loss of seasonal fluctuations in water level, altering the natural disturbance regime. In addition, colonization by nonnative invasive plants and senescence of native riparian species is a possible effect of flow alteration. Research in both Montana (Nyack River) and Alaska (Susitna and Talkeetna rivers) has shown that flooding-related disturbance is important in maintaining habitat diversity in riparian areas (Helm and Collins 1997, Bowen et al. 2003, Whited et al. 2007, Hanley 2008). In rivers where flow is regulated by dams, changes in the flooding regime can affect the distribution of both individual species and habitat types across the landscape (Nilsson et al. 1997, Whited et al. 2007). The complexity of such interactions has been investigated using modeling (e.g., Tealdi et al. (2011) that demonstrates the important influences of stochastic flow regimes and sediment transport on riparian vegetation. In both the Nyack and Talkeetna floodplains, species richness of vascular plants was highest at sites with the finest alluvium (Mouw et al. 2008). The spatial distribution of alluvium texture was determined by flow energy, and thus likely to be altered by hydroelectric development. In Sweden, plant species richness and dominance were affected by the distribution of anchor ice (Engstrom et al. 2011), which also would be expected to change downstream from dams.

Nutrient dynamics on the Susitna floodplain are affected by both downstream and upstream sources. The presence of spawning salmon in freshwater systems is an important, well-documented mechanism through which marine-derived nutrients (especially nitrogen and phosphorus) are transported into terrestrial ecosystems (Cederholm et al. 1999, Naiman et al. 2002), where they are cycled further by the wildlife that feed on salmon (Hilderbrand et al. 1999, 2004; Helfield and Naiman 2006). In the floodplain of the Tanana River (interior Alaska), hyporheic water is an important source of nitrogen for sandbar willow (*Salix interior*) on early successional silt bars (Koyama and Kielland 2010). That source of nitrogen may explain the sustainability of highly productive plant communities on the floodplain despite the apparently inadequate rates of nitrogen mineralization in the soil. Several recent studies have shown that subsurface hydrology directly affects nitrogen availability in the floodplain forests of Interior Alaska (e.g., Lisuzzo et al. 2008). Thus, flow regimes affect nutrient availability for plants through changes in hydrology, as well as through sediment input.

The riparian zones of Alaska rivers, including the Susitna, provide important foraging habitats for herbivores, principally moose, snowshoe hares, and beavers, which exert profound effects on vegetation succession and nutrient cycling (Helm and Collins 1997, Collins and Helm 1997, Kielland et al. 1997, Butler and Kielland 2008). Changes in habitat distribution and productivity of important forage species, such as willows, poplars, and paper birch, may affect the populations of these mammals. Conversely, herbivory is an important factor affecting species composition and successional patterns of riparian vegetation (Kielland et al. 1997, Hanley 2008). Thus, effects on herbivore populations may lead to changes in riparian plant communities. More generally, because aquatic and terrestrial food webs are coupled in riparian zones (Ballinger and Lake 2006), changes in flooding regimes may affect transfer of energy between riparian and terrestrial ecosystems in ways that are difficult to predict.

SYNTHESIS AND DATA-GAP SUMMARY

The purpose of this section is to describe and summarize the data gaps identified from the information review described in the preceding sections, based on comparison of the original SHP research with more recent studies and advances in research methods. In the preceding sections of this report, we have summarized briefly the scope of the original SHP studies, the methods used, the types of data collected, and important results. Evaluating the adequacy of the original SHP studies is a necessary step in identifying needs for further study to support the FERC licensing process for the proposed WHP.

The environmental program conducted for the original SHP studies produced a very large volume of data across a wide variety of wildlife species, including detailed information on distribution, abundance, demography, movements, life stages, food habits, and habitat use. Generally speaking, studies to collect basic data on many of those topics do not need to be repeated for the current licensing process; except as discussed specifically below, much of the existing basic information on life history, reproductive biology, food habits, and habitat use remains current enough for use in the current project.

Instead of repeating the same studies, we recommend that current study needs be focused principally on documenting current abundance and population trends in the project area and, for species of conservation and management concern, on information from elsewhere in the species ranges. The development and availability of new methods, most notably more advanced statistical methods and GIS spatial analyses, provide opportunities to obtain updated population estimates and densities and to evaluate changes that have occurred in wildlife habitats in the last 25–30 years.

To make effective use of the extensive historical data, however, a concerted effort will be required to locate old data sets, especially digital databases (a technology in its infancy at the time of the original SHP), and accompanying documentation. Original mapping products, such as master map copies or even original acetate and mylar overlays and aerial photographs, should be located for large-scale image scanning and conversion to digital format, with subsequent georectification and population of polygons with original data values. For example, the vegetation mapping boundary depicted in Figure 4 was obtained by scanning, converting, and georeferencing a paper map from a library copy of the original FERC application (APA 1983). Substantial additional work will be required to complete the process of converting the entire vegetation map, however.

Harza–Ebasco (1987) referred to locations at which original data were archived, such as the University of Alaska Fairbanks archives. Interviews of original investigators, many of whom still are active professionally, would be valuable in trying to track down original data sets. All such materials were supposed to have been turned over to APA at the end of the SHP, but institutional knowledge holds that was not done, however, making it likely that some original data may never be recovered.

Data gaps for some of the species and species groups studied for the SHP were reported in the draft mitigation plan, which was assembled for the SHP relatively far along in the project (LGL 1985a). The focus at that stage of the project was the need for studies during and after construction to evaluate project-related effects on productivity, population-level disturbance, and food availability. Additional needs for various terrestrial resources are described in the sections below. The highlights of the data gaps are tabulated in the summary matrix (Table 3).

The location and extent of specific study areas that will be needed to address data gaps for the WHP (discussed below) will vary among species and resources. The proposed impoundment zone that will be occupied by the Watana reservoir is a high-priority area for species that will lose habitat there. Surveys should cover all areas in the middle and upper reaches of the basin that would be affected by proposed infrastructure, access routes, and transmission lines. Farther

Table 3. Summary of potential data gaps identified for mammals, birds, amphibians, vegetation, wetlands, and wildlife habitats for the Watana Hydroelectric Project.

Resource	Potential Information Needs
MAMMALS	• Drainage-specific compilation of harvest data for all game animals and furbearers • Interviews with active harvesters trapping in WHP area
Moose	• Current estimate of population size and density in WHP area, especially for Watana impoundment zone in winter • Range maps of seasonal distribution and movements, using ADFG telemetry datasets • Current evaluation of SHP carrying-capacity model, for potential use in impact prediction and mitigation planning for the WHP
Caribou	• Comparison of historical and current range maps of seasonal distribution and movements for Nelchina and Delta herds, using ADFG telemetry datasets • Subherd numbers and distribution, especially in area north of WHP reservoir • GIS analysis of movements by GPS-collared females in WHP project area
Dall's Sheep	• Assessment of current condition and use of mineral licks on lower Jay Creek in relation to maximal elevation of proposed reservoir • Current estimate of sheep population in WHP area, including potential access corridors
Brown Bear	• Current estimate of population density in WHP project area, using either line-transect or CMR techniques • Assessment of use of salmon-spawning streams located downstream from WHP • Evaluation of seasonal use of Prairie Creek during salmon spawning • Evaluation of berry production in Watana impoundment zone and other areas directly affected by WHP
Black Bear	• Current estimate of population density in WHP project area, using either line-transect or CMR techniques • Evaluation of berry production in Watana impoundment zone and other areas directly affected by WHP
Wolf	• Mapping of pack territories and movements, using ADFG telemetry datasets • Current estimate of population density in WHP project area, using winter track surveys and SUPE technique
Beaver	• Fall surveys to document distribution of active colonies (lodges and food caches) in the middle and lower river (downstream extent to be determined from hydrological modeling) • Spring surveys to evaluate overwinter survival of active colonies
Wolverine	• Current estimate of population density in WHP project area, using winter track survey/SUPE technique
Other Furbearers	• Current estimate of population densities (marten, river otter, mink, lynx, red fox, coyote) in WHP project area, using winter track survey/SUPE technique or CMR technique from hair/genetic sampling • Surveys of aquatic furbearers (river otter and mink) downstream through middle reach of Susitna River
Small Mammals	• Small-mammal sampling transects in Watana impoundment zone (extensive trapping outside of areas affected directly by WHP not needed) • Current estimates of snowshoe hare population density in downstream riparian habitats, conducted annually to track population cycles

Table 3. Continued.

Resource	Potential Information Needs
BIRDS	
Raptors	• Current numbers and nest locations of Bald Eagles and Golden Eagles throughout WHP area, especially Watana impoundment zone and access/transmission line corridors • Surveys of cliff-nesting species (Gyrfalcons and Peregrine Falcons) in WHP area • Surveys of tree-nesting species in WHP area, especially Watana impoundment zone and access/transmission line corridors
Waterbirds	• Trumpeter Swan nesting survey in WHP area waterbodies • Brood surveys of species nesting in WHP area waterbodies and wetlands • Migration surveys (spring and fall) of waterbodies surveyed for the original SHP • Evaluation of use of WHP area by species of conservation and management concern
Shorebirds	• Breeding surveys using current protocol for landbirds (see below) • Evaluation of use of WHP area by species of conservation concern
Landbirds	• Breeding surveys using current protocol (point-counts with distance sampling and allocation according to habitat availability) • Evaluation of use of WHP area by species of conservation concern
AMPHIBIANS	
Wood Frog	• Auditory surveys in WHP area during spring breeding season, emphasizing waterbodies and wetlands in impoundment zone in upper river and riparian habitats downstream in middle river
VEGETATION, WETLANDS, and WILDLIFE HABITATS	
Mapping	• Recovery of original vegetation mapping products and documentation, including hard copies of maps for scanning, digital conversion, georeferencing, and entry into a unified GIS database for the entire WHP area, including upper, middle, and applicable portions of lower river • Current wetlands mapping of all areas potentially affected by WHP, including infrastructure footprints, impoundment zone, access/transmission line corridors (may be expedited by digital conversion of hard-copy wetland maps from NWI, with ground-truthing for verification of historical mapping accuracy) • Refinement of historical vegetation mapping at a larger scale than was done for the original SHP, and by mapping to AVC Level IV • Extension of vegetation mapping to all portions of access corridor alternatives
Habitat Evaluation	• Updated habitat evaluations from the original SHP and Susitna River Basin Study, using unified GIS map database and incorporating recent data on wildlife habitat use to create spatially explicit habitat evaluations across the range of wildlife species using WHP area • Current inventory of moose browse in WHP area, quantifying proportional removal of current annual growth • Reevaluation of habitat management options and candidate lands proposed for compensatory mitigation during the original SHP studies
Riparian Ecology Downstream	• Reexamination of historical study plots to evaluate changes since previous sampling conducted in early 1980s and 1995 • Hydrological modeling of seasonal flows for use in predicting project effects on ecological succession in floodplain communities

downstream, the study area extent in the floodplain of the lower river should incorporate areas likely to be affected by altered river flows during project operation, which are best identified through modeling after LIDAR data on channel morphology and elevation become available.

MAMMALS

The original SHP studies of large mammals relied extensively on aerial tracking of VHF radio-collars. Where available, those datasets should be compiled and combined with the existing telemetry data sets maintained by ADFG to develop maps of seasonal distribution and individual home ranges of mammals in the project area, using kernel home-range estimators rather than the minimum convex polygons used formerly, including comparison of changes through time.

For all species of big game and furbearers that are harvested by subsistence and sport hunters and trappers, updated harvest information should be assembled for the project area. Specifically, harvest numbers by species should be compiled for the smallest reporting units possible (UCUs or, in some cases, subunit). Harvest statistics for furbearers will be available only for those species that requiring sealing (wolf, wolverine, beaver, river otter). Other information can be obtained from trapper questionnaires and preferably personal interviews with harvesters using the area potentially affected by the WHP.

UNGULATES

Moose

Moose were identified as a key species during the SHP studies, mainly because of the potential loss of winter range in the proposed impoundment zones. Compensation requirements were not quantified, but a model was developed to estimate potential changes in the carrying capacity of the SHP area. That carrying-capacity model should be reevaluated to determine its relevance to the current project. Comparison of forage quality and browsing intensity in the proposed impoundment zone with existing data from ADFG's Nelchina study area south of the Susitna River would provide useful insights into habitat quality.

Current population estimates are lacking for the WHP area and should be obtained for both the upstream and downstream reaches of the basin, including potential access corridors. Surveys using the GSPE method (Kellie and DeLong 2006) should be conducted to provide estimates of the numbers of moose using the proposed WHP area. In particular, estimates are needed of the number of moose using the proposed reservoir during severe winters, when forage availability is limited by snow at higher elevations and the impoundment zone becomes more important.

Spatial analysis of seasonal range use and movements using ADFG's telemetry dataset, using kernel home-range estimation techniques, would provide valuable information on use of the WHP area, if sufficient recent data are available for animals collared in the area.

Caribou

Pitcher (1983) recommended continued tracking of collared animals, especially of the upper Susitna–Nenana subherd, to document range use in the area of the proposed development. The current status of subherds having different distribution patterns within the annual range of the Nelchina Herd needs to be clarified and an estimate of the number of animals that may reside in the upper Susitna–Nenana drainages should be obtained.

Detailed maps of caribou herd distribution, developed from existing ADFG telemetry data sets using kernel home-range estimation techniques and showing seasonal changes through time, would be of great value for understanding range use patterns and predicting impacts of the WHP. These maps should portray the use of the upper Susitna basin by animals from the neighboring Delta Herd.

Some of the potential impacts of the SHP on the Nelchina Herd were designated as potentially important and in need of further study (LGL 1985a). Most of those focused on the potential impact of the Watana impoundment as a barrier to caribou movement to higher value habitats or on human-caused disturbance (traffic, construction). No mitigation was recommended specifically for caribou, but post-construction studies to examine impacts not predicted were recommended. The potential impacts of ice shelving and other reservoir conditions on migrating caribou are important, yet poorly understood, factors that will be difficult to assess. Telemetry data from GPS collars should be analyzed using spatial analysis tools such as Brownian bridge movement models (Sawyer et al. 2009) to investigate seasonal movements of the herd in relation to the proposed WHP reservoir, access routes, and associated infrastructure.

Dall's Sheep

Sheep spent most of their time at elevations above the potential SHP impoundments and infrastructure, except for the parts of the Jay Creek mineral licks that were located in the Watana impoundment zone. The importance of four predicted impacts of the SHP could not be predicted and eight other predicted impacts were considered to be not important (LGL 1985a). Loss of lick sites due to leaching and erosion, blockage of sheep movements by the impoundment, and aerial and ground-based disturbance all were mentioned as needing further study. Monitoring during and after construction was recommended to evaluate mitigation needs.

Current estimates of the sheep population should be obtained for the WHP project area, especially in the Watana Creek Hills and alpine areas along the potential access corridors. The current extent of use of the mineral licks on lower Jay Creek should be described and the condition of the licks should be examined for changes through time, to assess the possibility of reservoir-related impacts.

CARNIVORES

Brown Bear

Information relevant to data gaps for brown bears was found primarily in the impact assessment and mitigation planning summary (LGL 1985b) and in Everitt et al. (1983). Data gaps for bears were described by LGL (1985a).

An obvious data gap is the lack of information on brown bears in the area downstream from Devils Canyon. Miller (1987) reported that "brown bear tracks along the salmon-spawning sloughs off the Susitna River were very common along sloughs, especially above the confluence with the Indian River." Downstream impacts on brown bears potentially could result from the project if salmon availability in those sloughs were affected by the WHP. In addition, no current estimates of the brown bear population are available for GMU 14 (Kavalok 2007). The current population density of brown bears in both the upstream and downstream parts of the WHP project area should be estimated using either the advanced line-transect technique of Becker and Quang (2009) or the CMR technique of Miller et al. (1997). Use of the latter method would allow direct comparisons with a greater number of other regional estimates obtained using the same method.

Food availability is a major factor regulating population size in brown bears. To assess the impacts of habitat loss, the relative importance of various foods must be understood. Although bears in the Susitna basin supplemented their diet with moose and fish, berry production was hypothesized to be the major factor limiting brown bear productivity (LGL 1985a). A data gap identified from the original SHP was the need for more information on the relative importance of different types of berries and their distribution across the project area (Everitt et al. 1983, LGL 1985a).

The king salmon at Prairie Creek provide a major nutritional resource for brown bears in the SHP study area (Miller 1987). Whether or not access to that resource influenced reproductive parameters of female bears was not known (LGL 1985a). Bears crossed the Susitna River to feed on salmon at Prairie Creek, but the possible effects of the impoundments on those movements were not well-understood. Miller (1987) cited Simpson (1986), who stated that grizzly bears in the vicinity of the Revelstoke reservoir in British Columbia "would cross a river but not the reservoir." Also at Revelstoke, Bonar (1985) noted "the radio-collared bears (both species) haven't crossed as often as they did before the water came up."

Black Bear

Information on data gaps for black bears was found in the impact assessment and mitigation planning summary by LGL (1985b) and in the description of a conceptual model that was developed to assess impacts of the project (Everitt et al. (1983). Data gaps for black bears also were addressed in LGL (1985a). Reliable census data for the area were lacking, due in part to the difficulty of censusing black bears in dense vegetation. Three potential impacts of the SHP were considered important (LGL 1985a): habitat loss in the impoundment zone; increased mortality due to hunters, poachers, and DLP; and blockage of bear movements, including juvenile dispersal.

Suitable habitat for black bears was mainly located downstream of Devils Canyon, although areas within and adjacent to the impoundment zones offered the best habitat upstream (e.g., spring foraging areas and den sites). The most obvious data gap is the lack of historical or current population studies of black bears in the basin downstream from Devils Canyon. Relatively complete studies were conducted in the upstream area in the early 1980s, but that information has not been updated in the intervening 25–30 years. As with brown bears, a survey to estimate the density of the black bear population in the WHP project area should be conducted to provide current population data. Either the advanced line-transect or CMR technique could be used, and the survey could be done concurrently with the brown bear survey.

More information was needed on black bear diets to evaluate impacts on habitat values (LGL 1985a). Berries clearly were a major food source for black bears in the upstream area, but little was known about the relative importance of various types of berries or their distribution in the project area (LGL 1985a). In the downstream area, only limited data were available about the relative importance and seasonal use patterns of various foods, primarily devil's club berries and salmon (Miller 1987).

Wolf

Wolves have been studied extensively in GMU 13 since the mid-1970s and are the subject of ongoing surveys for ADFG's intensive management program. Nevertheless, the area of the Susitna basin potentially affected by the WHP straddles three different GMUs (13, 14, 16) with different management mandates. The number of wolves and packs using the WHP project area currently is unknown, although indications are that it is substantially lower than during the SHP studies because of ongoing predator control efforts in GMU 13 and 16. A population survey of wolves in winter using a sample-unit probability estimator (Becker et al. 2004) would be appropriate for estimating wolf density and numbers in the WHP area. Mapping of pack territories and movements from existing ADFG telemetry datasets would provide useful background information for WHP environmental documentation.

FURBEARERS

Beaver

The beaver was the only furbearer species studied during Phase II of the SHP and the only furbearer studied in the middle river downstream from Devil Canyon to Talkeetna. The beaver studies conducted in the early 1980s were reasonably complete, but that information is now 25–30 years old, and no recent survey reports were located. Updated information is needed because the beaver is a keystone species in freshwater aquatic ecosystems and was selected as a key species for evaluating the impacts of the SHP.

The original FERC application hypothesized that beavers would benefit from controlled flow regimes, primarily through decreased spring flooding and an increase in the amount of open water beneath river ice during winter (APA 1983). LGL (1985a), however, concluded that managed water levels would have an adverse effect on beavers, particularly during fall and early winter. Fall surveys for beaver caches showed that beavers begin lodge construction during fall when, under natural conditions, water levels and flow rates stabilize (Woolington 1986). During operation of the SHP dams, however, water levels would have continued to rise above normal levels during early winter and lodges and caches constructed during fall would be susceptible to flooding by the rising water level, resulting in beaver mortality (LGL 1985a). Fall surveys of beaver lodges and caches are needed in the middle and lower reaches of the Susitna, extending as far downstream as the water levels are likely to be affected significantly by the WHP.

Overwinter survival of beavers was studied during two seasons of the original SHP studies. Overwinter survival is affected by breakup because lodges are susceptible to flooding and ice-scouring (Woolington et al. 1985). Dam construction upstream would affect breakup patterns because of higher winter flows. Current survey data are needed, particularly because breakup patterns may have changed in the past 25 years as a result of climate change. Altered winter and summer flows may also affect vegetation along the main channel, side channels, and sloughs. Although spring floods may destroy beaver lodges, they contribute to the formation of new channels and meanders, allowing beavers access to areas of new vegetation (LGL 1985a).

<u>Wolverine</u>

The original SHP studies conducted by ADFG provided detailed data on wolverines in the upper Susitna River basin. Wolverine distribution and habitat use in the Susitna basin probably have not changed appreciably since the 1980s, but the current population size is unknown. Improved survey methods have been developed since the original SHP studies, so a new population survey should be conducted, preferably using a sample-unit probability estimator (Golden et al. 2007) to evaluate the current population size in the WHP area.

<u>Other Furbearers</u>

Gipson et al. (1982) concluded that marten were more likely than other furbearers to be affected negatively by the Watana impoundment, due to their dependence on the forested habitats along the Susitna River and tributaries. Thus, current information on the marten population would be useful for predicting impacts of the project on furbearers. Gipson et al. (1984) stated that their results likely underestimated the true population size in the area. There are no recent estimates of the marten population in the WHP area. River otters were detected on track surveys conducted for the original SHP, but no attempt was made to estimate their population size or to describe habitat use in the downstream study area. No studies were conducted of lynx or coyote in the SHP area. Current population estimates of furbearer species in the WHP area should be obtained by flying track surveys in winter and using probability estimators (Becker 1991, Becker et al. 1998, Becker et al. 2004). That effort should include downstream surveys of aquatic furbearers (river otter and mink) in middle reach of the Susitna River. Alternatively, noninvasive population monitoring using genetic identification of hair or scat samples and CMR techniques (Long et al. 2008) could be used to estimate population sizes.

SMALL MAMMALS

The original studies conducted for the SHP provided a thorough sampling of the small mammal populations in the project area. Although 30 years have elapsed since those studies, it is unlikely that species distribution patterns or habitat use have changed significantly in the interim. Because of the often cyclical population fluctuations of small mammals and the lack of effective mitigation to offset population losses in the impoundment zone, it is questionable whether additional studies for the WHP are warranted. Establishing trapping transects for the Alaska tiny shrew and other species in the Watana impoundment zone may provide useful information for evaluating the effects of habitat loss on small mammals. Because of the ecological importance of the species as an herbivore, current estimates of snowshoe hare population density in downstream riparian habitats should be obtained; annual surveys should be used to track the population cycle of the species.

BIRDS

The relatively large number of bird species that occur on lists of conservation or management concern (Table 2), along with requirements under the federal Migratory Bird Treaty Act to avoid take of nesting birds, provides justification for conducting current surveys of a broad variety of species in the middle and upper Susitna basin for the WHP.

RAPTORS

Current data on the breeding distribution and status of birds of prey will be needed to evaluate the impacts of the WHP. Eagles will figure prominently in environmental planning for the project. Current data on Bald Eagle and Golden Eagle nest locations will be required under the BGEPA (USFWS 2007). Projected nest losses of both species to the original SHP led to development of proposed mitigation measures (LGL 1985a). Current information will be required to address take issues under the BGEPA and to develop an Eagle Conservation Plan for the project. Recently, the USFWS published new regulations (USFWS 2009b) to permit the taking of eagles and their nests in certain restricted situations. Those regulations may be applicable for the WHP, pending consultation with USFWS.

Peregrine Falcons did not nest in the SHP area during the early 1980s. The population and nesting distribution of the Peregrine Falcon have expanded substantially in interior Alaska since the original SHP studies, however, and it is possible that peregrines now nest in the middle and upper Susitna basin. Aerial surveys for cliff- and tree-nesting raptors should be flown in the middle and upper basin. These surveys should sample all suitable cliff-nesting habitats in the study area (i.e., cliffs, river and creek drainages). For tree-nesting raptors, a transect design could be used to estimate nesting density in larger areas of forested habitats.

WATERBIRDS AND SHOREBIRDS

Productivity surveys of breeding Trumpeter Swans were conducted every 5 years between 1975 and 2005 (no such survey has been conducted since 2005), and included coverage of waterbodies and wetlands in the project area. Those surveys documented a dramatic increase in the Trumpeter Swan population. The population surveys of breeding waterfowl that are conducted annually by USFWS in Alaska focus on regional population estimates and sample only a small portion of the WHP area. Surveys of waterbirds at the local project level have not been conducted in the WHP area since the early 1980s. Because of population changes in the intervening decades, surveys of breeding waterfowl should be conducted in the WHP area to identify important waterbodies and wetlands, primarily for species of conservation and management concern. Brood surveys on foot should be conducted to identify breeding species by verifying the presence of young and obtain productivity data. Breeding population surveys of shorebird species can be conducted simultaneously with landbird surveys (see below).

Aerial surveys of waterbirds during spring and fall migration should be conducted to provide current data on the seasonal use of waterbodies in the project area. The survey method of circumnavigating waterbodies at low altitude and slow speed, as was used in the original SHP studies, remains suitable for current surveys.

LANDBIRDS

Field surveys of breeding landbirds should be conducted in the WHP area in spring and early summer to obtain current population data. The original plot-based censuses of selected habitats (Kessel et al. 1982) provided good information for common species nesting in the study area, but less common species, including some species of conservation concern, are better sampled by using newer techniques involving different allocation of sampling effort. Specifically, point-counts with distance sampling, allocated in proportion to habitat occurrence, should be conducted. After it has been digitized, georeferenced, and evaluated for accuracy, the original SHP vegetation map could be used to allocate sampling effort.

AMPHIBIANS

WOOD FROG

Judging from surveys conducted in the lower Susitna basin and elsewhere in southern and central Alaska, it is likely that the wood frog occurs in the WHP area. Its distribution, abundance, and status are unknown there, however, so field surveys should be conducted in areas likely to be affected by the WHP. Standard methods (e.g., USGS 2010) involve auditory surveys of frogs calling during the breeding season in spring.

VEGETATION, WETLANDS, AND WILDLIFE HABITATS

Although several vegetation-mapping efforts have been completed for parts of the Susitna basin, adequate baseline maps for the area potentially affected by the WHP do not currently exist. A unified GIS database should be created from the various historical mapping efforts, potentially saving substantial time and effort, as opposed to undertaking a completely new mapping effort. The maps produced for the original SHP appear to exist only in hard-copy format and the originals have not yet been located, however. Those maps were hand-drawn on mylar or acetate overlays on aerial photos and topographic maps, so they will require scanning, digitizing, and georectification before they can be used in a modern GIS. To date, none of those mapping products appears to have been digitized, with the possible exception of the digital data produced for the mapping done by Kreig and Associates (1987), which needs to be located. If the original mapping products cannot be located and digitized, then it will be necessary to initiate a new mapping effort.

Similarly, wetland maps for the middle and upper basin currently exist only in hard copy; those maps needs to be digitized and combined in a single GIS database with available NWI data from downstream areas. NWI maps should suffice for general comparisons of wetlands for the preparation of environmental documentation, but more detailed field delineations eventually will be needed wetland permitting along the project access route and in other areas of construction, and would be useful for the required CWA Section 404(b)(1) analysis in the project EIS.

Although the original map products were data-based, field-verified, and thus probably quite accurate, the scale of mapping was primarily 1:63,360, whereas most habitat studies currently done for similar large development projects use much finer scales (1:10,000 or greater, depending on the available imagery). Hence, additional mapping at a finer scale should be considered in areas likely to be affected directly by WHP development. In addition, much of the potentially affected area occurs along the active floodplain of the Susitna River, where considerable changes probably have occurred in the intervening 25–30 years. Because of climate change and long-term trends for increased drying and shrub growth in Alaska in general (Sturm et al. 2001, Klein et al. 2005), previously mapped areas need to be ground-truthed to evaluate the extent of vegetative change in the 25–30 years since the SHP studies were conducted.

Mapping should be expanded as needed to cover the entire area potentially affected by current alternatives being considered for the WHP. The vegetation mapping effort for the original SHP did not include the northern part of the access route from the Denali Highway, parts of the current Chulitna and Gold Creek access options, and parts of the middle basin. The coverage and nomenclature applied to various areas mapped in different historical studies (SHP and the Susitna River basin Study) have been inconsistent, creating the potential for confusion and for gaps in coverage. Those problems can be resolved with a single GIS database.

Mapping for the SHP was primarily done to Level III (e.g., Willow Shrub) of the original Alaska Vegetation Classification (AVC; Viereck and Dyrness 1980), whereas the currently preferred level of detail for habitat classification is Level IV (e.g., Open Tall Willow Shrub) of the revised AVC (Viereck et al. 1992). The AVC Level-IV mapping done by Kreig and Associates (1987) should be verified and expanded in the WHP project area and along the potential access corridors. Ground-truthing will be necessary to evaluate current habitat conditions in the mapped area.

GIS technology provides a powerful tool enabling spatially explicit (map-based) evaluations of wildlife habitat use, but accurate mapping of vegetation and wetlands is necessary to provide the basis for habitat evaluation. As was explained earlier, the more recent mapping efforts in the Susitna basin area, which were based on classification of satellite imagery (BLM et al. 2002a, 2002b), have limited utility for wildlife habitat analysis because of the broad classes used. Because the mapping done for the original SHP was based on high-resolution aerial photography and extensive ground-plot data, it probably is more accurate than the recent mapping from satellite imagery, except where the vegetation has changed since the early 1980s.

Once a unified GIS database is available, it will be possible to reexamine the habitat evaluations from the original SHP (TES 1982) and Susitna River Basin Study (USDA 1985b) and update them with additional knowledge of habitat use gained since the SHP. The wildlife habitat evaluation for the original SHP (TES 1982) presented useful rankings of habitat values for individual species of wildlife, as well as multispecies summaries for each of 21 vegetation types. The habitat evaluation report indicated that ~9% of the habitat areas rated as "excellent" and ~41% of the areas rated as "good" wildlife habitat in the project area would be lost to the proposed SHP project, much of it good moose habitat. The habitat evaluation done for the downstream subbasins in the Susitna River Basin Study was a detailed, data-driven analysis that can be adapted to improve the habitat evaluation for the upper Susitna subbasin.

The extensive studies of the availability and utilization of shrubs in the study area provide excellent baseline information on moose habitat, but they are 25–30 years old. Habitats in the study area likely have changed since then, particularly in the active floodplain of the Susitna River. Given the likelihood that compensatory mitigation for loss of moose habitat will be needed, a current assessment of forage conditions should be conducted in the proposed impoundment zone and other areas likely to be affected by the WHP, using proportional browse removal of current annual growth to quantify browsing intensity.

Downstream from the proposed dam, attention needs to be devoted to the complex interrelationships of river morphology, hydrology, vegetation, herbivory, and nutrient cycling in riparian habitats on the Susitna River floodplain. The evaluation of riparian wildlife habitats should be based on detailed hydrological modeling of seasonal flow regimes and should incorporate findings from other floodplain studies of the dynamics of nutrient and energy flow and ecological succession in riparian vegetation communities. The lower extent of habitat studies downstream should be based on the outcome of the flow modeling. Study sites from the original SHP should be revisited to evaluate changes that have occurred since they were sampled in the early 1980s and mid-1990s by Helm and Collins (1997).

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Appendix A. Terrestrial mammal species reported to occur in the Susitna River basin.

English Name(s)	Scientific Name
Cinereus shrew, masked shrew, common shrew	*Sorex cinereus*
Pygmy shrew	*Sorex hoyi*
Dusky shrew, montane shrew	*Sorex monticolus*
Water shrew	*Sorex palustris*
Tundra shrew (formerly lumped with arctic shrew)	*Sorex tundrensis*
Alaska tiny shrew	*Sorex yukonicus*
Little brown myotis, little brown bat	*Myotis lucifugus*
Coyote	*Canis latrans*
Wolf	*Canis lupus*
Red fox	*Vulpes vulpes*
Lynx	*Lynx canadensis*
River otter	*Lontra canadensis*
Wolverine	*Gulo gulo*
Marten	*Martes americana*
Ermine, short-tailed weasel	*Mustela erminea*
Least weasel	*Mustela nivalis*
Mink	*Neovison vison*
Black bear	*Ursus americanus*
Brown bear, grizzly bear	*Ursus arctos*
Moose	*Alces americanus*
Caribou, reindeer	*Rangifer tarandus*
Mountain goat	*Oreamnos americanus*
Dall's sheep	*Ovis dalli*
Hoary marmot	*Marmota caligata*
Arctic ground squirrel	*Spermophilus parryii*
Red squirrel	*Tamiasciurus hudsonicus*
Beaver	*Castor canadensis*
Meadow jumping mouse	*Zapus hudsonius*
Northern red-backed vole	*Myodes rutilus*
Brown lemming	*Lemmus trimucronatus*
Singing vole	*Microtus miurus*
Root vole, tundra vole	*Microtus oeconomus*
Meadow vole	*Microtus pennsylvanicus*
Muskrat	*Ondatra zibethicus*

Appendix A. Continued.

English Name(s)	Scientific Name
Northern bog lemming	*Synaptomys borealis*
Porcupine	*Erethizon dorsatum*
Collared pika	*Ochotona collaris*
Snowshoe hare, varying hare	*Lepus americanus*

Sources: Kessel et al. (1982); APA (1985: Appendix E7.3); MacDonald and Cook (2009); continental modifiers of English names (e.g., *North American* river otter) have been dropped from this list.

Appendix B. Bird species recorded, or suspected to occur, in the Susitna River basin.

English Name	Scientific Name	Status [1]	Relative Abundance [2]
Greater White-fronted Goose	*Anser albifrons*	M	uncommon
Snow Goose	*Chen caerulescens*	M	uncommon
Brant	*Brant bernicla*	M	not present
Canada Goose	*Branta canadensis*	M	uncommon
Trumpeter Swan	*Cygnus buccinator*	B	fairly common
Tundra Swan	*Cygnus columbianus*	M	uncommon
Gadwall	*Anas strepera*	M, S	rare
American Wigeon	*Anas americana*	B	fairly common
Mallard	*Anas platyrhynchos*	B	common
Blue-winged Teal	*Anas discors*	M	rare
Northern Shoveler	*Anas clypeata*	B	uncommon
Northern Pintail	*Anas acuta*	B	common
Green-winged Teal	*Anas crecca*	B	fairly common
Canvasback	*Aythya valisineria*	M	uncommon
Redhead	*Aythya americana*	M	uncommon
Ring-necked Duck	*Aythya collaris*	M	rare
Greater Scaup	*Aythya marila*	B	common
Lesser Scaup	*Aythya affinis*	B	common
Harlequin Duck	*Histrionicus histrionicus*	B	fairly common
Surf Scoter	*Melanitta perspicillata*	B	fairly common
White-winged Scoter	*Melanitta fusca*	M	fairly common
Black Scoter	*Melanitta americana*	B	fairly common
Long-tailed Duck	*Clangula hyemalis*	B	fairly common
Bufflehead	*Bucephala albeola*	M	uncommon
Common Goldeneye	*Bucephala clangula*	B	fairly common
Barrow's Goldeneye	*Bucephala islandica*	B	fairly common
Common Merganser	*Mergus merganser*	B	uncommon
Red-breasted Merganser	*Mergus serrator*	B	uncommon
Ruffed Grouse	*Bonasa umbellus*	R	rare
Spruce Grouse	*Falcipennis canadensis*	R	fairly common
Willow Ptarmigan	*Lagopus lagopus*	R	common
Rock Ptarmigan	*Lagopus muta*	R	common
White-tailed Ptarmigan	*Lagopus leucura*	R	uncommon
Red-throated Loon	*Gavia stellata*	B	uncommon
Pacific Loon	*Gavia pacifica*	B	uncommon
Common Loon	*Gavia immer*	B	fairly common

Appendix B. Continued.

English Name	Scientific Name	Status [1]	Relative Abundance [2]
Horned Grebe	*Podiceps auritus*	B	uncommon
Red-necked Grebe	*Podiceps grisegena*	B	uncommon
Double-crested Cormorant	*Phalacrocorax auritus*	?	rare
Osprey	*Pandion haliaetus*	M	rare
Bald Eagle	*Haliaeetus leucocephalus*	B	uncommon
Northern Harrier	*Circus cyaneus*	B	fairly common
Sharp-shinned Hawk	*Accipiter striatus*	B	uncommon
Northern Goshawk	*Accipiter gentilis*	B	uncommon
Red-tailed Hawk	*Buteo jamaicensis*	B	uncommon
Golden Eagle	*Aquila chrysaetos*	B	fairly common
American Kestrel	*Falco sparverius*	M	rare
Merlin	*Falco columbarius*	B	uncommon
Gyrfalcon	*Falco rusticolus*	R	uncommon
Peregrine Falcon	*Falco peregrinus*	M	unknown
Sandhill Crane	*Grus canadensis*	M	uncommon
American Golden-Plover	*Pluvialis dominica*	B	common
Semipalmated Plover	*Charadrius semipalmatus*	B	uncommon
Spotted Sandpiper	*Actitis macularius*	B	common
Solitary Sandpiper	*Tringa solitaria*	B	uncommon
Wandering Tattler	*Tringa incana*	B, M	uncommon
Greater Yellowlegs	*Tringa melanoleuca*	B	uncommon
Lesser Yellowlegs	*Tringa flavipes*	B, M	fairly common
Upland Sandpiper	*Bartramia longicauda*	B	rare
Whimbrel	*Numenius phaeopus*	B	uncommon
Unidentified turnstone	*Arenaria* sp.	M	rare
Surfbird	*Aphriza virgata*	B	rare
Sanderling	*Calidris alba*	M	rare
Semipalmated Sandpiper	*Calidris pusilla*	B, M	uncommon
Least Sandpiper	*Calidris minutilla*	B	fairly common
Baird's Sandpiper	*Calidris bairdii*	B	uncommon
Pectoral Sandpiper	*Calidris melanotos*	M	uncommon
Long-billed Dowitcher	*Limnodromus scolopaceus*	M	uncommon
Wilson's Snipe	*Gallinago delicata*	B	common
Red-necked Phalarope	*Phalaropus lobatus*	B	fairly common
Black-legged Kittiwake	*Rissa tridactyla*	M	rare
Bonaparte's Gull	*Chroicocephalus philadelphia*	B, S	uncommon
Mew Gull	*Larus canus*	B, S	common

Appendix B. Continued.

English Name	Scientific Name	Status [1]	Relative Abundance [2]
Herring Gull	*Larus argentatus*	M, S	uncommon
Arctic Tern	*Sterna paradisaea*	B	fairly common
Parasitic Jaeger	*Stercorarius parasiticus*	M	rare
Long-tailed Jaeger	*Stercorarius longicaudus*	B	fairly common
Great Horned Owl	*Bubo virginianus*	R	uncommon
Snowy Owl	*Bubo scandiacus*	M	rare
Northern Hawk Owl	*Surnia ulula*	R	uncommon
Short-eared Owl	*Asio flammeus*	B?, M, S	uncommon
Boreal Owl	*Aegolius funereus*	R	rare
Belted Kingfisher	*Megaceryle alcyon*	B	uncommon
Yellow-bellied Sapsucker	*Sphyrapicus varius*	?	rare
Downy Woodpecker	*Picoides pubescens*	R	uncommon
Hairy Woodpecker	*Picoides villosus*	R	uncommon
American Three-toed Woodpecker	*Picoides dorsalis*	R	uncommon
Black-backed Woodpecker	*Picoides arcticus*	R	rare
Northern Flicker	*Colaptes auratus*	B	uncommon
Olive-sided Flycatcher	*Contopus cooperi*	B	uncommon
Western Wood-Pewee	*Contopus sordidulus*	B	rare
Alder Flycatcher	*Empidonax alnorum*	B	uncommon
Say’s Phoebe	*Sayornis saya*	B	uncommon
Eastern Kingbird	*Tyrannus tyrannus*	A	accidental
Northern Shrike	*Lanius excubitor*	B	uncommon
Gray Jay	*Perisoreus canadensis*	R	common
Black-billed Magpie	*Pica hudsonia*	R	uncommon
Common Raven	*Corvus corax*	R	common
Horned Lark	*Eremophila alpestris*	B	common
Tree Swallow	*Tachycineta bicolor*	B	fairly common
Violet-green Swallow	*Tachycineta thalassina*	B	fairly common
Bank Swallow	*Riparia riparia*	B	common
Cliff Swallow	*Petrochelidon pyrrhonota*	B	common
Black-capped Chickadee	*Poecile atricapillus*	R	uncommon
Boreal Chickadee	*Poecile hudsonicus*	R	fairly common
Brown Creeper	*Certhia americana*	B	uncommon
American Dipper	*Cinclus mexicanus*	R	uncommon
Golden-crowned Kinglet	*Regulus satrapa*	M	uncommon
Ruby-crowned Kinglet	*Regulus calendula*	B	common
Arctic Warbler	*Phylloscopus borealis*	B	fairly common

Appendix B. Continued.

English Name	Scientific Name	Status [1]	Relative Abundance [2]
Northern Wheatear	*Oenanthe oenanthe*	B	uncommon
Townsend's Solitaire	*Myadestes townsendi*	B	uncommon
Gray-cheeked Thrush	*Catharus minimus*	B	fairly common
Swainson's Thrush	*Catharus ustulatus*	B	fairly common
Hermit Thrush	*Catharus guttatus*	B	common
American Robin	*Turdus migratorius*	B	common
Varied Thrush	*Ixoreus naevius*	B	common
American Pipit	*Anthus rubescens*	B	common
Bohemian Waxwing	*Bombycilla garrulus*	B	common
Lapland Longspur	*Calcarius lapponicus*	B	abundant
Smith's Longspur	*Calcarius pictus*	B	uncommon
Snow Bunting	*Plectrophenax nivalis*	B	fairly common
Orange-crowned Warbler	*Oreothlypis celata*	B	uncommon
Yellow Warbler	*Dendroica petechia*	B	rare
Yellow-rumped Warbler	*Dendroica coronata*	B	common
Townsend's Warbler [3]	*Dendroica townsendi*	?	?
Blackpoll Warbler	*Dendroica striata*	B	fairly common
Northern Waterthrush	*Parkesia noveboracensis*	B	fairly common
Wilson's Warbler	*Wilsonia pusilla*	B	common
American Tree Sparrow	*Spizella arborea*	B	abundant
Savannah Sparrow	*Passerculus sandwichensis*	B	abundant
Fox Sparrow	*Passerella iliaca*	B	fairly common
Lincoln's Sparrow	*Melospiza lincolnii*	B	uncommon
White-crowned Sparrow	*Zonotrichia leucophrys*	B	abundant
Golden-crowned Sparrow	*Zonotrichia atricapilla*	B	uncommon
Dark-eyed Junco	*Junco hyemalis*	B	common
Rusty Blackbird	*Euphagus carolinus*	B?, M, S	uncommon
Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*	B	common
Pine Grosbeak	*Pinicola enucleator*	R	uncommon
White-winged Crossbill	*Loxia leucoptera*	B, S	fairly common
Common Redpoll	*Acanthis flammea*	R	abundant
Pine Siskin	*Spinus pinus*	B	uncommon

[1] M = migrant (transient); B = breeding; S = summering; R = resident; ? = uncertain (Kessel et al. 1982; APA 1985: Appendices E5.3 and E6.3).
[2] From Kessel et al. (1982) and APA (1985: Appendices E5.3 and E6.3).
[3] Added here by ABR, based on probable occurrence in lower basin (Matsuoka et al. 1997).