Kanuti National Wildlife Refuge
Biological Program Review

Final Report
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Executive Summary

- This report summarizes the findings and recommendations of the Kanuti National Wildlife Refuge biological program review conducted by a 14-member panel of invited research and management scientists on 24-25 July 2002, in Fairbanks, Alaska. The review will help ensure that the refuge's biological program supports the establishing purposes and that studies being conducted or proposed are appropriate, relevant, and attain stated objectives.

- The principal ecological drivers of the Kanuti National Wildlife Refuge ecosystem are hydrology, fire, and climate. The complexity and interrelationships of these factors and their influence on the distribution, abundance, and productivity of fish, wildlife and plants require refuge staff collaborate with research scientists affiliated with other agencies, institutions and universities. The Kanuti NWR biological program review panel developed the following recommendations:

- The Refuge Geographic Information System (GIS) should be further developed and supported by the refuge to better manage biological, sociological, and geophysical data.

- The refuge staff should develop and implement a Long Term Ecological Inventory and Monitoring Program by 2006 to examine the abundance and distribution of plants, terrestrial and aquatic invertebrates, fish, and wildlife resources and assess the environmental processes that may influence them. Kanuti NWR should review and adopt (if appropriate) current inventory and monitoring protocols developed by other agencies (e.g., National Park Service).

- The draft ecological systems model should be revised and updated to: (1) provide a greater understanding of environmental processes that may influence distribution and abundance of fish, wildlife, and plants and (2) identify and prioritize new studies.

- High-resolution aerial photography or satellite imagery should be procured to revise existing land cover classifications to better evaluate specific wildlife and habitat objectives.

- In concert with Service's Regional Fire Ecologist and the Interior Alaska Refuge Fire Management Officer, supplement the existing fire history database provided by the Alaska Fire Service with data on fire history prior to 1950 and other information that provides insight to the refuge's fire regime.

- Refuge staff should address potential effects of hydrology on fish and wildlife habitat by: (1) developing a hydrological model to predict stream discharge and the spatial extent of flooding; (2) designing and implementing an inventory of select rivers, streams, and

wetlands to address physical, chemical and biological characteristics; and, (3) based upon inventory data, design and implement a monitoring plan to examine potential change in water quality and abundance, and distribution and species richness of invertebrates and vertebrates.

- The 1993 Kanuti Refuge Fishery Management Plan should be implemented to: (1) determine the seasonal distribution of whitefish (*Coregonus* sp.) and northern pike (*Esox lucius*); (2) map the spatial distribution of spawning and wintering areas for priority species of anadromous and resident fish; and (3) determine migratory characteristics of whitefish.

- Kanuti NWR should continue to:

  – collaborate with Alaska Department of Fish and Game (ADF&G), Bureau of Land Management (BLM), and the National Park Service (NPS) to conduct moose (*Alces alces*) population trend surveys at 5-year intervals and annual moose composition surveys;

  – conduct surveys to monitor beaver (*Castor canadensis*) caches as an index to beaver distribution and relative abundance;

  – conduct off-road landbird point counts and breeding bird surveys in cooperation with the U.S. Geological Survey and Boreal Partners in Flight;

  – collaborate with Migratory Bird Management and interior Alaska refuges to monitor mid-continent greater white-fronted geese (*Anser albifrons*) via the annual aerial molting survey and banding program, and/or other method(s) deemed more effective by the Greater White-fronted Goose Working Group.

Contents

Review Panel

The Kanuti NWR biological program review was conducted by a 14-member panel of national and international scientists and land managers from state, federal and tribal agencies and academic institutions. In addition, the Kanuti NWR review benefited by written comments submitted by research and management scientists with the U.S. Geological Survey, University of Alaska, the U.S. Fish and Wildlife Service (Service), and the National Park Service.

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Introduction

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and when appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans. The National Wildlife Refuge System Improvement Act of 1997 specifically directs refuge staff to: "...provide for the conservation of fish, wildlife, and plants on refuges; maintain the biological integrity, diversity, and environmental health; and, monitor the status and trends of fish, wildlife, and plants" (Public Law 105-57).

The National Wildlife Refuge System conducts informal, annual reviews of their biological programs to evaluate current inventory, monitoring and research projects and assess the need to address new issues or concerns. Less frequent, formal evaluations of refuge management programs are also conducted using panels of scientific experts from within and outside the Fish and Wildlife Service to ensure a refuge biological program supports the establishing purposes and current priorities. Reviews help ensure that biological studies being conducted are appropriate, relevant, and attain stated objectives. This report summarizes the findings and recommendations of the Kanuti National Wildlife Refuge (Fig. 1) biological program review conducted by a panel of invited scientists (see pages 3-4) on 24-25 July 2002, in Fairbanks, Alaska.

Goals for the Kanuti NWR Biological Program Review

The goals of this review are to:

- Determine if the biological program supports the establishing purposes outlined in the Alaska National Interest Lands Conservation Act (ANILCA), the National Wildlife Refuge Improvement Act, and other Service policies regarding fish, wildlife and habitat management;
- Identify measures to: (a) improve fish, wildlife and habitat conservation and management on Kanuti NWR and (b) contribute to the ecological integrity of the National Wildlife Refuge System at regional and national scales;
- Identify inventory, monitoring, and research needs required to implement ecosystem management;
- Identify management priorities and strategies for inventory, monitoring, research, and habitat management plans;
- Help Kanuti NWR identify factors (e.g., personnel, funding, and support) that limit design and implementation of management and research studies.

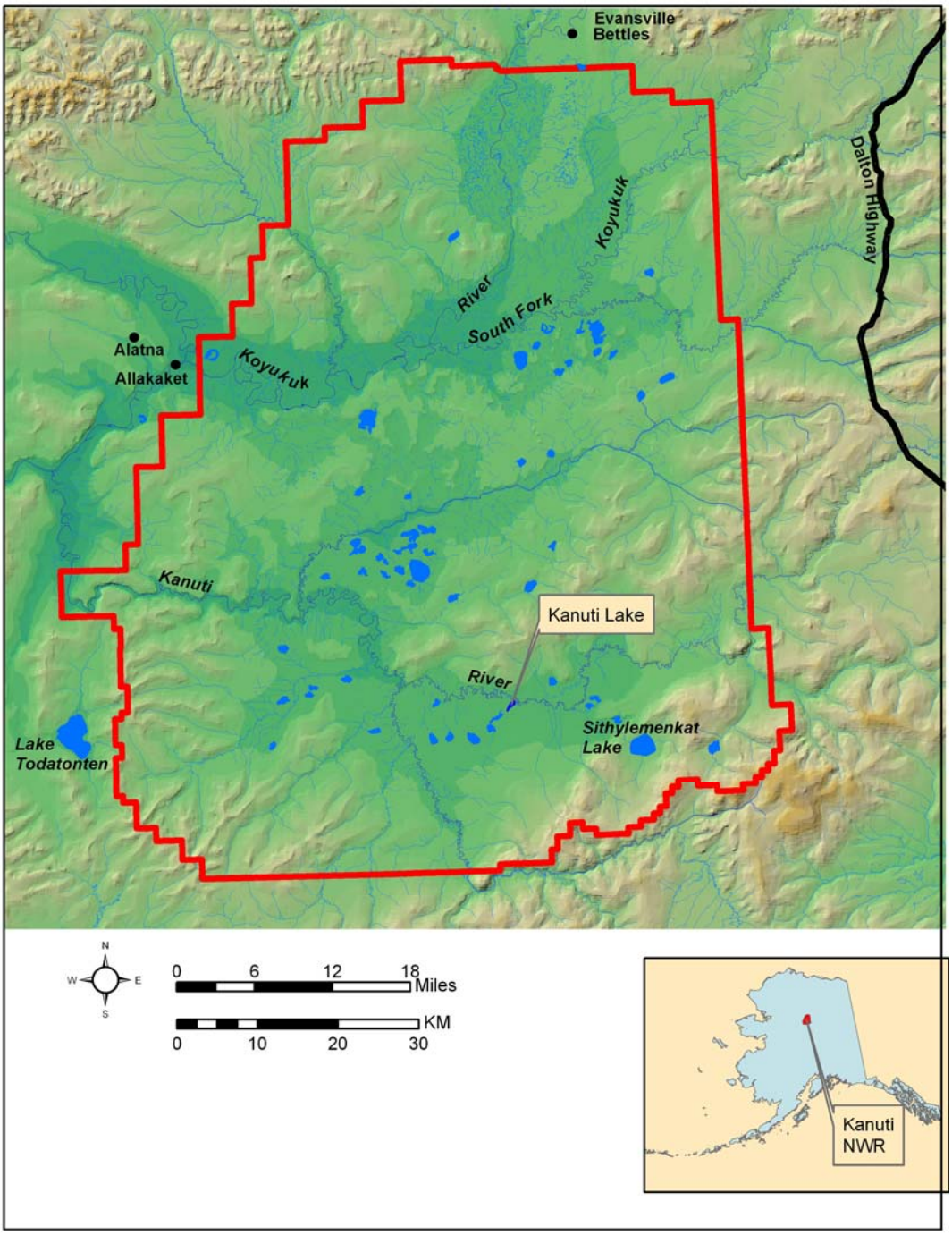

Figure 1. Kanuti National Wildlife Refuge boundary.

Implementing the Kanuti Refuge Biological Program Review

This review will be used by Kanuti NWR to help design and develop a long term inventory and monitoring program to evaluate potential changes in the distribution and abundance of fish, wildlife and plants. The document will also provide information on current and planned biological studies for the revised Kanuti NWR Comprehensive Conservation Plan.

The Kanuti Refuge Manager is responsible for implementing recommendations contained in this report. Compliance with recommendations in this review will be incorporated into the Refuge Manager's performance plan. The results of this review will guide the refuge's biological program from 2005-2015.

Alaska National Interest Lands Conservation Act (ANILCA)

The purposes for which the Kanuti NWR were established and shall be managed are mandated by §302(4)(B) of ANILCA:

(i) to conserve fish and wildlife populations and habitats in their natural diversity including, but not limited to, white-fronted geese and other waterfowl and migratory birds, moose, caribou (including participation in coordinated ecological studies and management of the Western Arctic Caribou Herd), and furbearers;

(ii) to fulfill the international treaty obligations of the United States with respect to fish and wildlife and their habitats;

(iii) to provide, in a manner consistent with the purposes set forth in subparagraphs (i) and (ii), the opportunity for continued subsistence uses by local residents; and,

(iv) to ensure, to the maximum extent practicable and in a manner consistent with the purposes set forth in paragraph (i), water quality and necessary water quantity within the refuge.

Comprehensive Conservation Plan (CCP)

Comprehensive Conservation Plans are mandated by ANILCA to provide broad policy guidance and long-term goals and objectives for managing refuges. A CCP helps ensure: (1) the mission of the National Wildlife Refuge System and the purposes of the refuge are met; (2) that national policy is incorporated into refuge management; (3) opportunities for the public to participate in development of management directions; (4) a systematic process for decision making on the refuge including establishing broad strategies for refuge management programs and activities; and (5) a basis for evaluating accomplishments.

CCPs are updated approximately every 15 years to accommodate changes in legislation, public interests, and scientific knowledge. The original Kanuti NWR CCP (1987) is presently under revision.

Public involvement is incorporated into the CCP through the development of an environmental impact statement (EIS) for each plan. National Environmental Policy Act (NEPA) processes associated with the EIS involve scoping meetings with the public to help identify issues and the range of actions, alternatives, and impacts to be addressed during plan development or revision.

The public also has opportunities to comment on draft plans prior to finalization.

The Kanuti NWR CCP will incorporate results and recommendations of the biological program review. Refuge staff will also develop more detailed step-down plans on specific resource or land management issues following the CCP. Step-down plans describe management strategies, provide implementation schedules, and outline methods used to fulfill management goals and objectives. An Inventory and Monitoring Plan for Kanuti NWR will be developed as a step down plan under the CCP and will incorporate recommendations from this biological program review.

Inventory and Monitoring Plan

The primary objectives of the draft Kanuti National Wildlife Refuge Inventory and Monitoring Plan are to design and implement studies to examine physical, chemical, and biological elements, their relationships and processes, and changes thereof, via studies conducted by refuge staff and collaborating agencies. The inventory and monitoring program will result in a better understanding of species abundance, distributions, habitat requirements, and fundamental ecological relationships. This information will provide baseline data to assess impacts of potential site-specific development projects within the refuge or in similar habitats outside the refuge. Inventory and monitoring program components will evaluate species-habitat associations and identify the range of biological and physical conditions that limit distribution. Refuge personnel will identify priority species and environmental variables to monitor potential environmental and biological change given current personnel, time, logistic, and budget constraints.

Kanuti National Wildlife Refuge Draft Vision Statement

Kanuti NWR will be managed for its wild character and its natural biodiversity, as driven by biological and physical processes throughout time. Inventory and monitoring of wildlife populations and habitats important to Alaska, the United States, and the world will be the focal points of research and management efforts. Studies will focus on the physical and biological components of the boreal forest region, their ecological relationships, and their response to human activity. Stewardship of Kanuti NWR will strive to maintain ecosystem integrity, while providing for subsistence opportunities and nature-dependent recreation. Management will foster partnerships with, but not limited to, government agencies, other organizations, and the public, including local communities.

Conservation Concerns on Kanuti Refuge

- The Trans-Alaska Pipeline is within 16 km of the Kanuti NWR eastern boundary and crosses over 20 tributaries draining into the refuge. Because of the potential for an oil spill, the Fisheries Management Plan for Kanuti National Wildlife Refuge (1993) identified the need to map critical fish overwintering and spawning habitats in these areas.
- The increase in visitors using the Dalton Highway corridor could result in potential impacts to fish, wildlife and habitat resources through: 1) higher probability of oil and fuel spills; 2) greater recreational use of fish and wildlife populations; 3) greater potential

for the introduction of invasive plants; and, 4) an increased likelihood of conflicts between user groups.

- Although most of the Kanuti NWR is currently closed to nonlocal hunting of moose, conflicts between local subsistence and nonlocal hunters occur because local subsistence hunters believe that nonlocal hunters harvesting moose from adjacent, open areas of the refuge lower populations on other refuge lands (e.g., inside the controlled-access area).
- Local subsistence and nonlocal hunters are concerned about potential effects of bear and wolf predation on moose populations.
- Little is known about the reproduction, survival and habitat requirements of fishes that are important to subsistence users.
- Mid-continent greater white-fronted geese nesting in interior Alaska may be declining as a result of greater mortality compared to other segments of the population. However, migration patterns of greater white-fronted geese between interior and arctic areas are unknown. Potential changes in the breeding distributions of interior and arctic breeding populations confound population trend data. Because white-fronted geese are an important waterfowl resource throughout the Central and Mississippi flyways, the refuge is collaborating with the Service's Migratory Bird Management division and the U.S. Geological Survey Alaska Science Center to better understand origins and distributions of breeding pairs, migration corridors, and wintering areas.

The Kanuti National Wildlife Refuge Biological Program Review Process

Refuge staff conducted literature searches, compiled and reviewed reports and publications, and met with collaborating agencies to prepare for the biological program review. The biological program review panel received a briefing package that provided background information on legal mandates of the refuge, the physical and biological environment, public use, threats to resources, and past and current biological projects. Draft inventory and monitoring goals and objectives were included to stimulate discussion during the review.

The review consisted of two days of discussion that were videotaped and later transcribed by refuge staff to produce meeting transcripts. Presentations by Lisa Saperstein, Wildlife Biologist, and Merry Maxwell, Biological Technician, Kanuti NWR, provided background information on field facilities, access, and public use on the refuge; landscape features, including terrestrial and aquatic habitats; and a summary of the current biological program. Dr. Patricia Heglund, Regional Refuge Biologist, organized and conducted the review. Dr. Heglund explained the purpose of the biological program review, legal mandates of National Wildlife Refuges, and requested the review panel identify the ecological drivers of Kanuti Refuge.

Discussions on the first day of the review focused on ecological drivers, draft biological goals and project objectives, an inventory and monitoring program, justification and methods to monitor physical processes (e.g., river and stream flow and spring floods, snow depth, rainfall), and current and proposed work on beaver and moose). During the morning of the second day, the panel discussed current and proposed work on caribou, wolves, bears, snowshoe hares, small mammals, birds, fish, and wood frogs.

The panel then ranked potential projects based on titles derived primarily from the briefing documents. Projects were ranked high, medium, or low. The process to identify priority projects was hampered by the following factors:

- project titles did not allow adequate understanding of the justification, objectives, methods, and management implications of the proposed work;
- projects described in the briefing document and revised per panel discussions and recommendations were not ranked;
- two ranking procedures (an informal hand count of votes for high, medium and low and handouts of project titles that were ranked and turned in) resulted in two ranking scores;
- projects conducted by the Refuge versus projects designed and implemented by other Service programs or agencies were viewed and ranked differently among panel members; and,
- discussions during the review that resulted in changes in project design or methods and new ideas were not incorporated into project titles described and ranked by panel members.

The approach ultimately used to prioritize projects was based on average ranks calculated for each topic from written rankings. High, medium, and low ranks were scored three, two, and one point, respectively. To calculate the average, the sum of the ranks for each project was divided by the number of panel members (14), although the denominator varied because not all panel members ranked all projects. Average scores and rankings were as follows: $\geq$2.4 – 3.0 (high), <2.4 – 1.7 (medium), <1.7 (low). Recommendations in this report are based on these rankings, meeting transcripts, and written comments.

Dr. Patricia Heglund accepted a position with the U.S. Geological Survey, fall 2002. A draft biological program review report was completed in April 2003 during which time Eric Taylor was hired as the Regional Refuge Biologist. The report was subsequently completed by Eric Taylor and Lisa Saperstein.

Results

1. Environmental Monitoring

The primary ecological drivers influencing plant and wildlife populations in Interior Alaska, including the ecosystems that comprise the Kanuti NWR include hydrology, fire, and climate. Because the expertise of refuge staff is focused on species and populations, the complexity and interrelationships of hydrology, fire, and climate and their influence on the distribution, abundance, and productivity of fish, wildlife and plants require refuge biologists to collaborate with research scientists affiliated with other agencies, institutions and universities. The refuge is surrounded by other federal land conservation units spanning northern Alaska (Figure 2). A cooperative and coordinated monitoring program for hydrology, fire, and climate would decrease the overall costs for individual land management units, ensure consistent methods, and provide comprehensive geographic coverage.

Climate is one of the drivers of the Kanuti NWR ecosystem and it influences all ecological processes occurring on the refuge. Refuge staff should: (1) examine available data on climatic conditions to determine if they provide sufficient detail to correlate weather events with observed changes in the environment, (2) assess the refuge's role in filling identified data gaps, and (3) consider ways to monitor environmental factors that could indicate long-term changes in climate, such as timing of break-up and green-up.

Refuge staff should improve upon and maintain its comprehensive Geographic Information System (GIS) to include a hierarchical classification for vegetation, geomorphology, and hydrology. The GIS should include data on elevation, permafrost occurrence, proposed travel or energy corridors, archeological sites, fire boundaries, and fish and wildlife concentration areas (e.g., fish spawning and overwintering sites, lakes used by molting geese, and mineral licks used by ungulates), as well as available remote sensing data. The GIS would allow the refuge manager, biologists, outreach specialists, and subsistence specialists to coordinate projects and information needs.

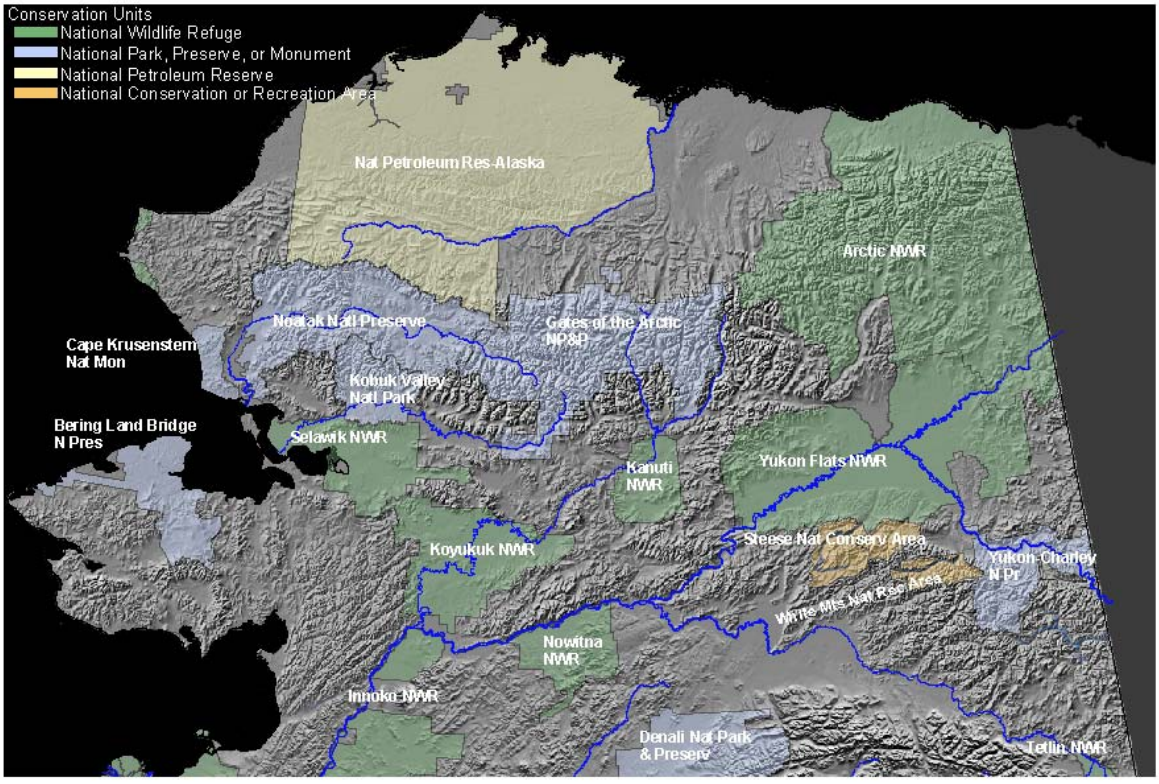

Figure 2. Administrative boundaries of National Wildlife Refuges (USFWS), National Parks, Preserves, and Monuments (NPS) and the National Petroleum Reserve-Alaska (BLM) in northern Alaska.

Panel Recommendations: Environmental Monitoring

High Priority

- Ensure that biological, sociological, and geophysical data in the refuge's GIS are current and meet data standards. Data on land ownership, topography, soils, geology, hydrology, archaeological sites, roads, dams, weirs, culverts, power lines, survey markers, benchmarks and fish and wildlife resources should be obtained or digitized from existing information.
- Refuge staff should identify the specific objectives, methods, sampling design and inference in current efforts to collect data on snow depth and snow density. Refuge staff should continue to collaborate with the National Resource Conservation Service and determine the interests of other agencies and institutions including the U.S. Geological Survey and the Water and Environmental Research Center, University of Alaska Fairbanks because frequency, depth, density, and distribution of snow affect: (a) hydrology, (b) survival, behavior, and condition of fish and wildlife resources, and (c) plant phenology and vigor.

Medium Priority

- If existing weather data are insufficient to assess conditions on the refuge to the degree necessary to meet objectives, refuge staff should establish additional remote weather stations or other data loggers. Development of a hydrologic model, as suggested by the panel (see Section 4), will require the collection of precipitation and other relevant data.
- Kanuti NWR staff should determine the availability of air and water quality data from the Environmental Protection Agency, National Oceanic and Atmospheric Administration, National Weather Service, and the U.S. Geological Survey. If these data are unavailable, the refuge should evaluate the appropriateness, feasibility, and cost of purchasing, installing, and maintaining remote stations to collect and store these data. Water quality data may be collected in conjunction with hydrologic models or aquatic inventories (see Section 4).

2. Vegetation

The Kanuti National Wildlife Refuge Inventory and Monitoring Plan should document what is currently known about vegetation and vegetation communities on the refuge. The plan should also identify objectives, management implications, temporal and geographic scales, and methods to assess species abundance, distribution, and community associations of plants. Refuge staff should design and implement a collection-based inventory to be validated by the University of Alaska Museum and archived at the refuge headquarters.

Human activities within or adjacent to refuge habitats may increase the likelihood that exotic or invasive plants become established within refuge boundaries. Residents of Native villages adjacent to the refuge routinely use the refuge, and the number of visitors traveling along the Dalton Highway is predicted to increase in the next several decades. Invasive species along the Dalton Highway could spread via rivers or wind to colonize gravel bars and other disturbed areas, such as burns. For example, white sweet clover (*Melilotus alba*) is currently spreading along the Dalton Highway and occurs where the highway crosses the Kanuti River.

Kanuti NWR may serve as an appropriate control site to examine the ecological and physical characteristics and functions of intact, un-logged, forested riparian habitats versus logged

riparian forests in the Tanana Basin. Collaborative research with the State of Alaska Department of Natural Resources, Alaska Department of Fish and Game, University of Alaska, U.S. Forest Service, U.S. Army Corps of Engineers and the Service could help address the functions of these habitats as: (a) wildlife transportation corridors, (b) flood control, (c) contaminant and sediment traps, and (d) nutrient input and temperature regulation for rivers and streams.

Panel Recommendations: Vegetation

High Priority

- Objectives and methods to inventory plants on the refuge should be included in the Kanuti National Wildlife Refuge Inventory and Monitoring Plan. Refuge staff should work with the University of Alaska Museum, U.S. Geological Survey, National Park Service, the Service's Regional Refuge Botanist, and others to design and implement plant inventory and collection protocols to better understand plant diversity and distribution.
- Refuge staff should review vegetation monitoring efforts adopted by the National Park Service and other research institutions (e.g., University of Alaska Fairbanks Long Term Ecological Research Stations at Toolik Lake and Bonanza Creek) to assess the potential benefits of collaboration and cooperation.
- Kanuti NWR should acquire high-resolution aerial photography or satellite imagery to revise existing land cover classifications to better evaluate specific wildlife and habitat objectives.
- Refuge staff should consider combining the land cover classification system with spatially explicit layers of geology, soils, elevation, hydrology, and structures (e.g., roads, villages, pipelines, bridges) to better assess how environmental characteristics and processes affect populations and distributions of fish, wildlife and plants.

Low Priority

- In collaboration with the Regional Invasive Species Coordinator, develop a monitoring protocol for invasive plants.
- Kanuti NWR staff should develop objectives and methods to monitor flowering times for a specific suite of vascular plants in specific locations (e.g., Bettles/Evansville or Alatna/Allakaket) and evaluate the potential to collaborate with Native residents to collect field data to monitor potential affects of climate change.

3. Fire

Fire is one of the major modifiers of the landscape on Kanuti NWR and is considered a driver of the boreal forest ecosystem. Almost 62% (408,776 hectares) of Kanuti NWR has burned since 1950 according to an Alaska Fire Service database (Fig. 3). Large fire events occasionally occur, such as in 1990 and 1991 when a total of 260,207 hectares burned, and most recently in 2004 when 70,204 hectares burned. Despite the prevalence of fire on interior Alaska's landscape, fire intervals, successional patterns, fire effects on wildlife, and the relationships between fire, climate, and vegetation remain poorly understood.

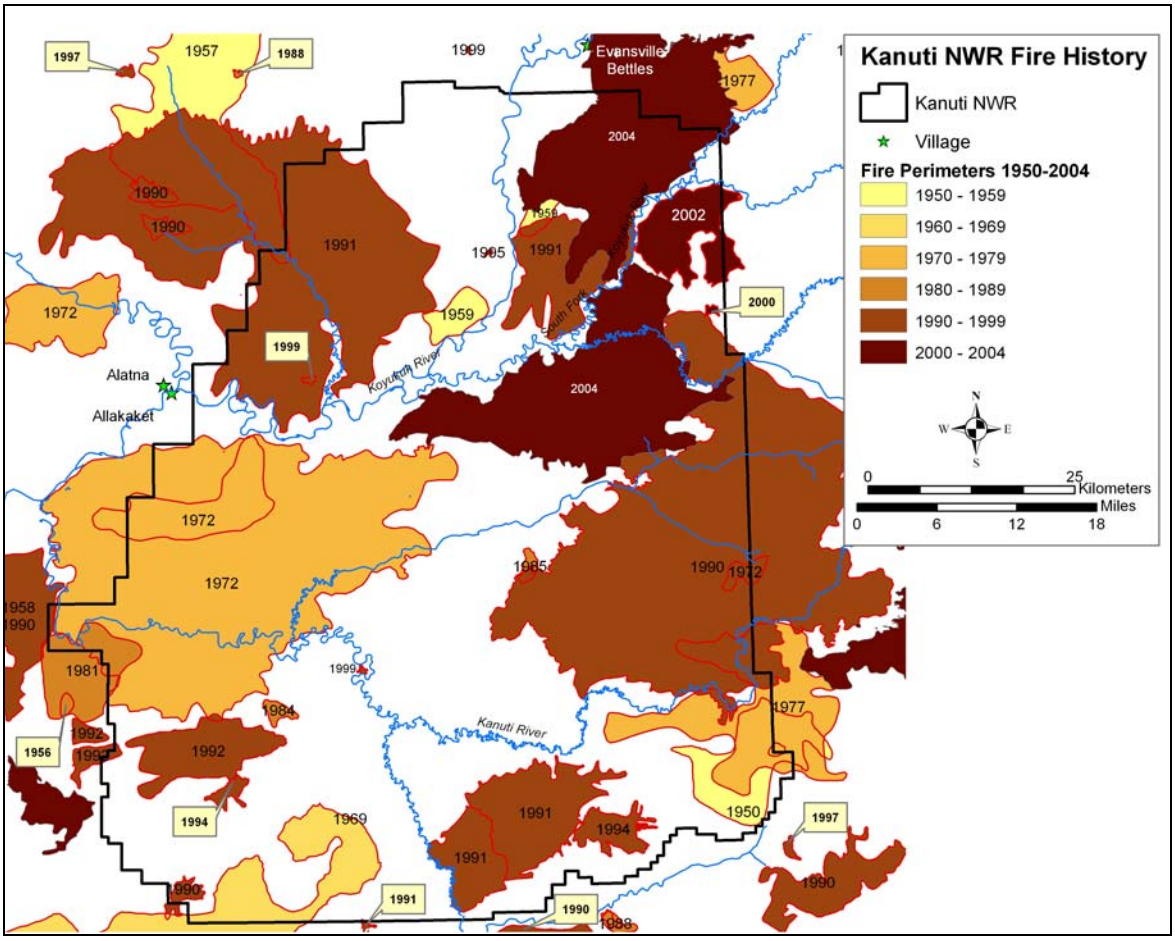

Figure 3. Fire history on Kanuti NWR, 1950-2004. Fires greater than 404.6 ha (1,000 acres) in size were mapped between 1950 and 1987, fires greater than 40.5 ha (100 acres) in size were mapped 1987–present (Alaska Fire Service).

Two post-1990 fire projects are currently being conducted on Kanuti NWR. The first project tracks changes in the small mammal community in burned black spruce (*Picea mariana*) and burned spruce-birch (*Betula papyrifera*) habitats. Small mammal data collected between 1993-03 were analyzed by the University of Alaska Fairbanks, Institute of Arctic Biology (Rexstad 2003). The second project monitors changes in vegetation and fire fuels on eight permanent transects. Data collected from 1991-99 are currently being analyzed via contact; this analysis will allow refuge staff to design an appropriate sampling plan for new research. Both projects were designed and implemented to provide a greater understanding of post-fire affects on small mammals and plants.

In addition to the studies described above, refuge staff should collaborate with the University of Alaska, Alaska Fire Service, U.S. Forest Service (USFS), the BLM, and the Service's Fire Program to develop field and analytical methods to map fire severity and plant regeneration to better understand fire effects on plants and wildlife.

Panel Recommendations: Fire

High Priority

- In concert with the Service's Regional Fire Ecologist and the Interior Alaska Refuge Fire Management Officer, construct fire history maps by assessing areas that have not burned since 1950 and by verifying information from fire records contained in the Alaska Fire Service database.

Medium Priority

- Collaborate with the Regional Fire Ecologist and the Interior Alaska Refuge Fire Management Officer to determine and implement methods to map in real time the location, severity, and rate of spread of new fires on Kanuti NWR to improve management of future fires and predict vegetation response from fire.
- In concert with the Regional Fire Ecologist and the Interior Alaska Refuge Fire Management Officer, develop models to predict fire behavior and occurrence relative to the distribution and availability of wildlife habitat.
- Continue monitoring composition and abundance of vegetation and fuel variables along previously established, permanent transects at time intervals to be determined following assessment of existing transect data. Work with the Regional Fire Ecologist and the Alaska Fire Effects Task Group to evaluate establishing new transects in habitats and areas in recent burns to better assess potential changes in specific vegetation assemblages across the refuge.
- Continue to monitor small mammals in post-fire habitats to examine potential change in species abundance and composition. The refuge should also consider changing from an annual to a longer sampling interval as the annual rate of vegetation change decreases.
- Assess landbird abundance and species richness in different-aged burns concurrent with collecting information on vegetation, to develop predictive models of landbird use in post-fire seral stages (see Section 7).

4. Aquatic Ecology and Hydrology

To better understand flow and flood events of the Kanuti and Koyukuk rivers and their tributaries, Kanuti NWR staff should support and collaborate with the U.S. Geological Survey, Water and Environmental Research Center-University of Alaska Fairbanks, and the Service's Water Resources Branch to develop a hydrologic model. Hydrologic data would allow refuge staff to better understand: annual variation in the hydrologic cycle; potential effects on fish, wildlife and habitat resources; and, provide baseline data for water rights acquisition. The Service's Water Resources Branch will monitor water flow on major tributaries of Kanuti NWR during 2006-2012 for acquisition of water rights. Refuge staff should determine the merit and feasibility of maintaining stream gauges for long-term monitoring and assess the feasibility of examining water quality (e.g., nutrient chemistry, sedimentation, turbidity, dissolved oxygen). Understanding hydrologic flow and water quality may be especially important for streams crossing the Dalton Highway corridor and proposed mineral extraction sites. Refuge staff should collaborate with the Service's Contaminants and Fisheries programs to identify sources and extent of contaminants and potential impacts to fish and aquatic habitats.

Beaver (*Castor canadensis*) significantly modify hydrology via the construction of dams across

small rivers, streams, and sloughs. Refuge staff should develop specific objectives to assess the role of beaver on riverine and wetland hydrology including, but not limited to: mapping the distribution of caches via aerial surveys, determining the relationship between beaver populations and caches, monitoring seasonal hydrologic change resulting from beaver dams, and examining change in beaver impoundments.

Figure 4. Wetland habitats on Kanuti Refuge include over 2,700 small to medium-sized (< 405 km^2) freshwater lakes.

Kanuti NWR contains the suite of aquatic habitats typical of interior Alaska including rivers, streams, lakes, ponds, and other waters (e.g., oxbows, sloughs). The values and functions of these habitats include flood control, water quality, nutrient recharge, water storage, and habitat for plants, invertebrates, fish, and wildlife. Riparian habitats form a transition from aquatic to terrestrial habitats and serve as nesting and foraging habitat, cover, and travel corridors to many species.

Although the Kanuti NWR and cooperating agencies have collected limited data on chemical and biological properties for a small number of lakes, the refuge staff should expand the inventory and monitoring of lakes, ponds, rivers, and streams to better understand the values and roles of these habitats to fish and wildlife. A new surficial geology map (Hamilton 2002) may provide a good foundation to stratify sampling to make refuge-wide inferences. The National Park Service

is currently evaluating methods to inventory aquatic resources in national parks in Alaska. To expand the understanding of the waters in this region and establish an effective program for tracking the condition of freshwaters within the refuge, staff should collaborate with the National Park Service and the Service's Water Resources Branch.

Panel Recommendations: Aquatic Ecology and Hydrology

The panel identified numerous techniques for assessing water resources on Kanuti NWR, although many of the suggestions would only be feasible given extensive collaboration and funding. The refuge would benefit from establishing automated gauging stations over longitudinal profiles (i.e., headwater streams to a medium-sized river) of river systems representative of major river types (e.g., brown water, clear water; see Milner et al. 1997). Such a design would allow hydrologic (e.g., flood routing and attenuation) and biological (e.g., benthic macroinvertebrate taxonomic richness, periphyton abundance) parameters to be compared among river types. In addition, gauging otherwise similar streams, with and without beaver activity, would allow the refuge to quantify the role of beavers in modifying hydrology and water storage and in creating habitat (see Naiman 1984, 1986).

Refuge staff should assess the feasibility of examining the ecological consequences of spring flooding (see Gordon et al. 1992). Potential effects of spring flooding include a reset mechanism for riparian habitats, removing sediment from spawning substrates, and creating side channel/ slough habitat important for rearing fish and for invertebrates.

The approach adopted by the National Park Service to monitor lakes and streams would allow the refuge to develop indices of biomass production and taxonomic structure. Due to the limited information on waters in Interior Alaska, the monitoring program should sample lakes across the entire refuge rather than implement an intensive sampling effort on a small number of lakes to better characterize the full range of conditions and variability. Monitoring the surface area, shoreline slope, and water depths of a sample of wetland types will also allow refuge staff to assess long-term effects of climate change.

Inventory or monitoring studies assessing the diversity, abundance or biomass of freshwater invertebrates should limit identification to the genus level for insects, most other arthropods, and some other phyla (e.g., mollusks). Collection of diatoms, which are easier to preserve and identify, should also be considered to allow comparison to paleolimnology data.

Use of permanent photo points will document phenology of streams (e.g., progression of frazil and surface ice) and seasonality of riparian vegetation (leaf out, green-up and leaf fall).

High Priority

- To develop a hydrologic model to predict stream discharge and the spatial extent of flooding, refuge staff should collaborate with the U.S. Geological Survey, the Water and Environmental Research Center-University of Alaska Fairbanks, and the Service's Water Resources Branch. The hydrologic model should be designed to address biological and legal mandates. To provide the data needed for this model, refuge staff should work with these agencies to design and implement studies to examine water flow and flood events of select streams and rivers. Studies should include a diversity of stream and river origins (e.g., spring, beaver-influenced).

- Draft an inventory study to sample select rivers, streams, and wetlands (lakes, ponds, sloughs, oxbows) to examine physical, chemical and biological variables. Refuge staff should collaborate with the National Park Service, University of Alaska Fairbanks, U.S. Geological Survey and other refuges to draft questions to be addressed, objectives, methods, database management, and products. Records of incidental observations of wildlife occurring in these habitats should follow an accepted protocol. Concurrent with designing and implementing an aquatic habitat inventory plan, refuge staff should collaborate with these agencies to design and implement a long-term monitoring plan for lotic and lentic waters in the refuge. Potential questions and objectives of a monitoring plan include addressing climate change influences on water quality, invertebrate and vertebrate richness, abundance and distribution; and a baseline for contaminants.

5. Fisheries

Sixteen species of fish are known to occur in refuge waters including Chinook (*Oncorhynchus tshawytscha*), Coho (*Oncorhynchus kisutch*) and Chum (*Oncorhynchus keta*) salmon. Fish are an important subsistence resource for villages adjacent to the refuge. Ten years of data collected by agencies between 1982 and 2000 determined that an average of about 4,000 whitefish and 6,000 salmon were harvested annually by the villages of Allakaket, Alatna, Evansville, and Bettles (Brown 2003). Salmon harvest has declined since the mid-1980s, particularly during recent years when salmon runs have been poor.

The Kanuti NWR fisheries program is currently guided by the Fishery Management Plan, Kanuti National Wildlife Refuge (1993); however, the refuge and the Fairbanks Fish and Wildlife Field Office should determine the need to revise and update the Fishery Management Plan.

In 2003, Kanuti NWR and the Fairbanks Fish and Wildlife Field Office assessed species occurrence, age, and strontium levels of whitefish in two rivers and associated wetlands. In May 2004, Kanuti NWR and the Fairbanks Fish and Wildlife Field Office deployed radio transmitters in three whitefish species in the Kanuti River wetlands, upstream from the mouth of the Kanuti Kilolitna River. Additional transmitters were deployed in the South Fork Koyukuk River and Kanuti River wetlands in 2005. This study will provide valuable information on distribution, age structure, and habitat requirements of feeding, spawning, and overwintering whitefish.

Panel Recommendations: Fisheries

High Priority

- Review and revise, if necessary, the 1993 Kanuti NWR Fishery Management Plan.
- Design and implement surveys to determine the seasonal distribution of whitefish (see current study described above) and northern pike.
- Identify and map the spatial distribution of spawning and wintering areas for priority species of anadromous and resident fish.
- As part of the seasonal distribution of whitefish study, develop and implement an otolith microchemistry study to determine if anadromous whitefish migrate from marine waters at the mouth of the Yukon River into the upper Koyukuk River including Kanuti NWR habitats (completed in 2003).

- Determine the sizes of salmon runs for all three species that occur on the refuge to better evaluate escapement goals and management for subsistence users. If possible, Kanuti NWR and the Fairbanks Fish and Wildlife Field Office should evaluate representative stream systems to determine if salmon runs are principally limited by: (1) number of spawners reaching spawning habitat, (2) amount/quality of spawning habitat, and/or (3) rearing capacity (juvenile habitat).

6. Wildlife Resources

Thirty-seven species of mammals, approximately 125 species of birds, and one amphibian occur within Kanuti NWR. Wetlands, rivers, streams, forests, shrub/scrub, and riparian habitats provide breeding, wintering and migration areas. Although the general natural history, distribution, and habitat requirements for many of these species are known, specific data on population trends, habitat selection, predator-prey relationships, and response to environmental perturbations (e.g., fire, flood) are lacking. The Kanuti NWR biological program review panel examined current and proposed inventory, monitoring, and research wildlife projects.

Moose

Kanuti NWR is mandated by ANILCA to conserve, protect, and maintain a natural diversity of fish, wildlife, and plants. As part of this mandate, the refuge, in cooperation with the Alaska Department of Fish and Game, monitors the moose population both on the refuge, as well as in greater Game Management Unit 24.

Although moose densities in Kanuti NWR are relatively low (0.12 to 0.29 moose/sq. km for surveys conducted 1989 - 2004), they are an important resource for both local subsistence and nonlocal hunters. To adequately monitor the population trend, refuge staff collaborates with the Alaska Department of Fish and Game, Bureau of Land Management, and the National Park Service to conduct moose surveys at 5-year intervals and trend counts on an annual basis. Current survey design includes Kanuti NWR and adjacent areas of Game Management Unit 24. To assess potential changes in age/sex ratios, refuge staff conducts annual composition surveys. Late winter surveys and spring calving surveys are of limited value. Spring surveys are affected by timing and intensity of the surveys because the number of cows with calves and proportion of twins change daily; consequently, estimates of calf production and predation may be biased as the result of survey timing. Furthermore, the low moose density on Kanuti NWR likely prohibits collecting an adequate sample size to monitor productivity and survival. Both population trend and age/sex ratio surveys should be based upon stated objectives and methods that address variance, power, bias and cost.

Refuge staff should collaborate with the Alaska Department of Fish and Game, National Park Service, University of Alaska Fairbanks, U.S. Geological Survey and other agencies to initiate new research on moose. To better understand population trend data and the role of fire on distribution, productivity, and condition of moose, refuge staff should design and implement a moose browse study. To assess body condition (e.g., body size, fatness, calf weight), survival productivity, and seasonal distribution, refuge staff should design and implement a long-term biotelemetry project. The uncertainty of correctly identifying the cause of mortality of neonate and older moose carcasses that are located via incidental observations, precludes assessing the role of predators via this method.

Panel Recommendations: Moose

High Priority

- Continue to collaborate with the Alaska Department of Fish and Game, Bureau of Land Management, and the National Park Service to conduct moose population surveys at 5-year intervals.
- Continue to collaborate with the Alaska Department of Fish and Game and Bureau of Land Management, to conduct annual moose composition surveys to monitor age and sex ratios.

Medium Priority

- Design and implement a long-term biotelemetry moose study on the Kanuti NWR to assess body condition, productivity, survival, and seasonal movements.
- Collaborate with the Alaska Department of Fish and Game and the University of Alaska to evaluate moose habitat quality as affected by fire.

Caribou

Caribou (*Rangifer tarandus*) periodically occupy the refuge in winter as a result of the Western Arctic Herd moving in from the north or, less frequently, the Ray Mountains Herd entering the refuge from the south. Recent estimates of herd size are 490,000 for the Western Arctic Herd in 2003 (J. Dau, ADF&G, pers. comm. 11/24/2004) and 1,736 for the Ray Mountains Herd in 2000 (Stout 2001). Caribou are generally found on the refuge in scattered small bands (generally <50 caribou each) but do not remain throughout winter. At times, larger groups of caribou from the Western Arctic Herd move onto the refuge. Western Arctic Herd caribou moved onto the refuge in mid-November 2003, and over 1,000 remained on the refuge until at least early March 2004. During this period, about half of the Western Arctic Caribou Herd was distributed throughout GMU 24 (J. Dau, pers. comm.). Prior to this, the last large influx of caribou occurred November 1992 when 60,000 caribou meandered onto the western Kanuti flats for about two weeks and 1,200 - 2,000 animals remained on the refuge until late April. Due to the low numbers and infrequent use by caribou, annual surveys to assess population trend, distribution, and habitat are of limited value and not cost-effective.

Panel Recommendations: Caribou

Current efforts by refuge staff to conduct monthly overflights to document caribou numbers and distribution are sufficient given the current level of use; however, the refuge should document both spatial (area covered) and temporal (time devoted to survey) components as a measure of survey effort.

Beaver

Beaver influence hydrology, wetlands, and riparian habitats in the boreal forest and serve as prey for red fox (*Vulpes fulva*), coyotes (*Canis latrans*), wolves (*Canis lupis*), black bears (*Ursus americanus*) and grizzly bears (*Ursus arctos*). Beaver also provide food and pelts for local residents. Because of the importance of beaver to the interior Alaska ecosystem, refuge staff should conduct beaver cache surveys to index the abundance and distribution of the beaver population. Refuge staff tested a beaver cache survey technique during 2002-03 based upon the moose population trend survey design (see Ver Hoef 2002). The 2-year pilot survey provided

reasonable estimates for the numbers and distribution of beaver caches on the refuge (Table 1). However, research is needed to address the importance of not detecting beavers that den in stream banks. It is also unknown if the survey design could detect a population decline if colony size decreased without an associated change in the number of caches. Panel members suspected that prime habitat on the refuge may be colonized already, serving as a source population for more marginal habitat. The refuge should investigate methods to address these problems to increase the effectiveness of cache surveys.

Refuge staff should assess the role of beavers in modifying hydrology and water storage and in creating habitat on Kanuti NWR by reviewing the scientific literature. If this review reveals knowledge gaps in understanding how beaver ecology influence wetland hydrology in the boreal forest of interior Alaska, refuge staff should collaborate with research institutions and universities to develop and implement appropriate research. Annual surveys are likely required to assess the effectiveness of beaver cache surveys and the extent to which beaver dams influence impoundments; however, refuge staff should determine if surveys may be conducted on a less frequent basis (e.g., every 3 to 5 years) to decrease cost without a significant loss of predictive probability.

Table 1. Results of beaver cache surveys on Kanuti NWR, 2002-03.

	Samples per Stratum			Cache Count by Stratum					
Year	High	Low	Total	High	Low	Total	Est. Caches	Standard Error	90% CI
2002	62	38	100	348	67	415	1,148.07	97.41	985 – 1,311
2003	46	30	76	343	48	401	1,337.09	112.09	1,153 – 1,521

Panel Recommendations: Beaver

High Priority

- Continue to conduct surveys to monitor beaver caches as an index to the distribution and relative abundance on Kanuti NWR. Survey design should be defined or clarified (i.e., refuge staff should assess how sample size, survey frequency, and spatial extent of survey affect cache index variability).

Medium Priority

- Assess the feasibility of examining the spatial extent and timing (i.e., when a dam affects local hydrology) of impoundments caused by beavers. Consider mapping impoundments using GIS within the same sampling units used for beaver cache surveys to compare survey results with the number and spatial extent of impoundments.

Low Priority

- Develop an estimate for the number of individual beaver associated with a cache.

Wolves and Bears

Black and brown bears and wolves comprise top level carnivores in the interior Alaska ecosystem and are considered by scientists and the public as representatives of intact and healthy ecosystems. Both species of bears and wolves are also sought after by local subsistence and

nonlocal hunters. Kanuti NWR is mandated by ANILCA to conserve and protect these species to maintain the natural diversity of fish, wildlife and plants.

Bears and wolves are predators of moose, caribou, beaver, and hare (*Lepus americanus*). In some areas of Alaska, densities of moose are viewed by local and non-local residents and the Alaska Department of Fish and Game as below the sustainable harvest level due to predation. To address this issue, ADF&G established Intensive Management Areas in which predator control and habitat enhancement techniques can be used as tools to increase local moose populations.

An adequate understanding of predator-prey relationships on Kanuti NWR and surrounding areas requires not only long-term monitoring of the populations, distributions, and densities of moose, wolves, and bears, but also their habitats. Refuge personnel must have an understanding of the quantity, quality, and availability of forage for moose, and the levels of local subsistence and nonlocal harvests, to better understand processes that influence populations.

Wolf surveys are more easily designed and implemented than bear surveys as aerial snow track surveys can be conducted during winter. Wolf telemetry studies are further facilitated by both the relative ease of tranquilizing and tracking them in late winter, as well as the need to only radio-collar several members of a pack. Aerial wolf surveys and telemetry projects have been conducted on Kanuti NWR.

Bears are generally counted during late spring, after recent emergence from dens and prior to leaf-out. However, coniferous forest cover prevents a thorough survey, especially for black bears which frequently occur in forested habitats. Radio-collaring bears generally require that they be trapped on the ground rather than darted from the air, making it logistically more difficult to obtain adequate sample sizes. Genetic analyses of hair samples to identify individuals have been used to estimate bear numbers; however, establishing and monitoring a sufficient number of hair collection sites to develop a population estimate on Kanuti NWR is cost- and time-prohibitive. Despite the challenges of obtaining estimates for black and brown bears, refuge biologists should collaborate with the Alaska Department of Fish and Game and other agencies to review current methods and/or test new techniques to estimate bear populations.

Panel Recommendations: Wolves and Bears

Medium Priority

- Collaborate with ADF&G and other agencies to implement existing survey designs or develop new survey designs to monitor the distribution, abundance and densities of bears and wolves.
- Implement regional guidance on recording incidental observations of bears and wolves during aerial overflights and field work.

Snowshoe Hares

The snowshoe hare cycle likely represents the greatest change in a vertebrate population in the boreal forest; however, Kanuti NWR has never estimated hare abundance or distribution of hares nor monitored their population. Information about the hare cycle on Kanuti NWR has been derived from incidental observations on the refuge and from data collected in more accessible areas of interior Alaska, particularly along the Dalton Highway. Although studies suggest synchrony in the hare cycle across the boreal region of North America, regional synchrony has not been explicitly demonstrated for interior Alaska (Paragi 1999).

Panel Recommendations: Snowshoe Hares

Medium Priority

- Using aerial surveys, track surveys, or pellet counts, refuge staff should implement a study to index the snowshoe hare population. Periodicity of the survey will depend on objectives. Refuge staff should work with other Alaska refuges, National Park Service, University of Alaska, Alaska Department of Fish and Game, and National Parks Canada to design and collaborate on snowshoe hare monitoring projects so as to better understand the hare-lynx population cycle in the boreal forest.

Low Priority

- Assess the use of browse surveys to index the snowshoe hare population.

Furbearers

Little is known about furbearers on Kanuti NWR despite their ecological role and the economic and cultural importance of trapping. Available data consist of miscellaneous trapping records, fur sealing data, and incidental observations of tracks in winter. Tracks of lynx (*Lynx canadensis*), marten (*Martes americana*), otter (*Lutra canadensis*), wolverine (*Gulo gulo*), red fox (*Vulpes vulpes*), and wolves are routinely encountered during winter overflights of the refuge. An effort was made to stratify the refuge for furbearer occurrence based on overflights in 1997, but a more thorough survey was not conducted following the stratification. Furbearer distribution and relative abundance will shift as new areas burn and previous burns evolve through different seral stages (Paragi et al. 1996, 1997). Some populations of furbearers, such as lynx, will also be highly dependent on timing of the hare cycle. Recent advances in the use of videography to conduct aerial furbearer track surveys could be a promising technique for Kanuti NWR.

Panel Recommendations: Furbearers

Medium priority

- Kanuti NWR should collaborate with the Alaska Department of Fish and Game and other agencies to assess the merit and feasibility to conduct aerial furbearer surveys to document distribution and relative abundance.

Small Mammals

Small mammals exhibit population cycles that influence the distribution and abundance of their foods (vegetation) and predators (e.g., fox, coyote, raptors). Refuge biologists have little knowledge about species diversity beyond general statewide range distributions, which change as new species are detected or ranges are expanded. For example, a new species of shrew for Alaska, *Sorex yukonicus*, was discovered in 1997. Information for small mammals on Kanuti NWR is limited to the long-term study on species composition and relative abundance in relation to fire (Section 3), the integrated terrestrial inventory initiated in 2004 (Section 7), and a few opportunistic trapping efforts in which specimens were provided to the University of Alaska Fairbanks Museum. Recommendations for Kanuti NWR to inventory, monitor, and conduct research on small mammals are provided in both the Fire and the Integrated Terrestrial Inventory sections.

Birds

Kanuti NWR provides breeding habitat for approximately 110 species of birds. No fewer than 21 waterfowl species (ducks, geese, and swans) breed on the refuge, with many found in the Kanuti and Koyukuk rivers and their associated wetlands. Canada geese (*Branta canadensis*) and greater white-fronted geese are the only geese breeding on Kanuti NWR. Lesser scaup (*Aythya affinis*), American wigeon (*Anas americana*), green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), bufflehead (*Bucephala albeola*), and northern shoveler (*Anas clypeata*) are likely the most abundant ducks breeding on the refuge.

The number of mid-continent greater white-fronted geese nesting in interior Alaska appears to have declined in recent years (Spindler 2001). The Service's Migratory Bird Management Office (MBM), in cooperation with the U.S. Geological Survey and interior Alaska refuges, are currently assessing populations, molting areas, and wintering areas to gain a better understanding of potential limiting factors. In 2000, MBM initiated aerial line transect surveys on Kanuti NWR in early July to estimate the number of molting greater white-fronted and Canada geese (Saperstein 2002). The annual survey covers most of the potential goose habitat on the refuge. Refuge staff conducted an annual (1995-02) survey on a segment of the Kanuti River via canoe to provide a productivity index of greater white-fronted and Canada geese (Martin 1998, Saperstein 2005).

Figure 5. Approximately 110 species of birds, including lesser yellowlegs (*Tringa flavipes*) breed on Kanuti Refuge.

No fewer than 40 species of migratory passerines breed on the Kanuti NWR. The most abundant species include alder flycatcher (*Empidonax alnorum*), Swainson's thrush (*Caltharus ustulatus*), American robin (*Turdus migratorius*), varied thrush (*Ixoreus naevius*), orange-crowned warbler (*Vermivora celata*), yellow warbler (*Dendroica petechia*), yellow-rumped warbler (*Dendroica coronata*), northern waterthrush (*Seiurus noveboracensis*), white-crowned sparrow (*Zonotrochia*

leucophrys), and dark-eyed junco (*Junco hyemalis*).

Common resident species include great-horned owl (*Bubu virginianus*), gray jay (*Perisoreus canadensis*), common raven (*Corvus corax*), black-capped chickadee (*Poecile atricapilla*), boreal chickadee (*Poecile hudsonica*), white-winged crossbill (*Loxia leucoptera*), and common redpoll (*Carduelis flammea*).

Refuge biologists conduct two Breeding Bird Survey (BBS) routes. All routes implemented under the original Alaska Off-Road Point Count (AKORPC) program were discontinued to implement routes run biennially under the Alaska Landbird Monitoring Survey (ALMS) program (Handel and Cady 2004). Data gathered from the AKORPC program, based on subjectively located routes, were used to develop ALMS, which features a more statistically rigorous random sampling design. The BBS, AKORPC and ALMS were all developed to monitor landbird population trends on continental and/or regional scales but provided limited data for the Kanuti NWR. The refuge recently implemented an integrated terrestrial inventory program (KANINV) to examine breeding landbirds, vegetation, small mammals, and invertebrates (see Section 7). The KANINV uses point count methods for birds that follow the Alaska Landbird Monitoring Survey (ALMS) protocol (Handel and Cady 2004). No fewer than 3 of the 60+ systematically randomly located plots will be visited each year. Table 2 summarizes the landbird surveys conducted on Kanuti NWR.

Table 2. Type, frequency and location of landbird surveys conducted on Kanuti NWR. Breeding Bird Survey (BBS), Alaska Off-Road Point Count (AKORPC), Alaska Land Bird Monitoring Survey (ALMS) and the Kanuti Integrated Terrestrial Inventory Program (KANINV) surveys are listed from 1993-2004.

Name	Type	Year Survey Conducted	Location
Kanuti Canyon	BBS[1]	1993-95, 1998-04	Kanuti River Canyon
Koyukuk River	BBS	1993-95, 1998-9, 2001	upriver of Allakaket
Kanuti Lake	BBS	2004	middle Kanuti River
Taiholman Needleleaf	AKORPC[2]	1993	Taiholman Lake
Broadleaf Scrub	AKORPC	1993-95	near Kanuti Canyon
Taiholman Broadleaf	AKORPC	1993-95, 1998-02	Taiholman Lake
Taiholman Tundra	AKORPC	1993-95, 1999-02	Taiholman Lake
Tundra Burn	AKORPC	1994-95	upriver of Allakaket
Bettles Road	AKORPC	1994-95, 1998-01	Evansville to VOR Lake
Koyukuk Burn	AKORPC	1994-95, 1998-02	1991 Koyukuk burn
Koyukuk Needleleaf	AKORPC	1994-95, 1998-02	Koyukuk River near Peavey Creek
Four Corners	ALMS[3]	2003	North of Fish Creek
Minnkokut	ALMS, KANINV[4]	2003, 2005	Minnkokut Lake
Chalatna	ALMS	2003	Kanuti Chalatna Creek
Kanuti Cabin	KANINV	2004	West of Kanuti Lake
Dune Lake	KANINV	2004	North of Nolitna Creek
Kaldolyeit	KANINV	2004	West of Big Kaldolyeit Lake

[1] Conducted under auspices of the Continental Breeding Bird Survey (BBS) Program
[2] Conducted under auspices of the Alaska Off-Road Point Count (AKORPC) Program
[3] Conducted under auspices of the Alaska Landbird Monitoring Survey (ALMS) Program
[4] Conducted under auspices of the Kanuti NWR Integrated Terrestrial Inventory (KANINV) Program

Panel Recommendations: Birds

High Priority

- Continue off-road point counts and breeding bird surveys in cooperation with the U.S. Geological Survey and Boreal Partners in Flight.
- Continue collaboration with Migratory Bird Management and interior Alaska refuges to monitor mid-continent greater white-fronted geese via the annual aerial molting survey and banding program, and/or other method(s) deemed more effective by the Greater White-fronted Goose Working Group.

Medium Priority

- Within the Boreal Program for Regional and International Shorebird Monitoring (Boreal PRISM), design and implement a boreal-forest, breeding shorebird population monitoring study. The Kanuti NWR should consider supporting studies on boreal shorebird species that show continental declines such as lesser yellowlegs, solitary sandpiper, and Wilson's snipe.
- Conduct aerial swan surveys in cooperation with MBM at 5-year intervals.
- Support projects that address avian species of concern including the solitary sandpiper (*Tringa solitaria*), olive-sided flycatcher (*Contopus cooperi*), blackpoll warbler (*Dendroica striata*), and rusty blackbird (*Euphagus carolinus*).
- Expand the North American aerial breeding pair survey on Kanuti NWR by adding transects identified by MBM to monitor populations and distribution of waterfowl on and adjacent to Kanuti NWR.

Wood Frog

In response to the increasing number and range of reported abnormalities in frogs, the Service initiated a preliminary investigation of abnormal amphibians on National Wildlife Refuges across the country. The goals of this effort were to identify refuges with significant numbers of abnormal amphibians, and to investigate what role, if any, environmental contaminants might play in causing the abnormalities.

Between 2000 and 2004, the Service examined over 4,700 wood frogs (*Rana sylvatica*) from five National Wildlife Refuges in Alaska, including selected locations on the Kenai, Arctic, Innoko, Yukon Delta, and Tetlin Refuges. Although wood frogs occur on the Kanuti NWR, surveys for abnormal frogs on the refuge have not been conducted.

Types of abnormalities are consistent among all refuges, the most common being missing or shrunken limbs or parts of limbs. Established causes of anuran abnormalities include the *Ribieroia odontae* parasite, failed predation attempts, chemical exposure, ultraviolet (UV) radiation and combinations of these factors. Abnormalities were documented in all refuges sampled. Sites at the Yukon Delta Refuge had the lowest abnormality prevalence at 2.3% (11/486 frogs) and the Kenai Refuge had the highest prevalence at 9.4% (279/2956 frogs).

The Service is continuing to work on this issue by focusing on the following objectives:

- Continue the study of abnormal frogs on previously surveyed refuges and conduct initial sampling on other refuges in Alaska that have wood frogs;
- On refuges where the initial study found >3% abnormalities in wood frog populations in two

out of three years, identify stressors at the site that may contribute to these abnormalities; and,

- Take steps to identify potential causes of abnormalities through evaluation of stressors in the field and laboratory experiments.

Panel Recommendations: Wood Frog

High Priority

- Participate in statewide and national surveys as requested by the Anchorage Fish and Wildlife Field Office.

Medium Priority

- Map and survey breeding ponds for egg masses, and malformed versus intact frogs.

7. Integrated Terrestrial Inventory

Refuge staff initiated an inventory of terrestrial biological resources in 2004 as the result of guidance stated in ANILCA to conserve fish and wildlife populations and habitats in their natural diversity as well as recommendations of the Kanuti NWR biological program review panel. The current inventory program is designed to catalog the diversity of breeding birds, habitats, small mammals, and terrestrial invertebrates found on the refuge. It will be an integral component of the Kanuti NWR Inventory and Monitoring Plan.

Early inventory studies conducted from 1982-2002 were largely restricted to areas accessible via floatplane or boat or considered unique (e.g., Kanuti Canyon). Most of these studies addressed waterfowl distribution and abundance, although observations of other wildlife were also recorded. Habitat characteristics including species, distribution, relative abundance, percent cover, and density of plants, and plant associations, were usually not collected. Consequently, little is known about plant communities or the habitat requirements of plants and wildlife on the refuge.

In December 2003, Kanuti NWR biologists devised a sampling plan to meet refuge goals and objectives to inventory plants, breeding migratory landbirds, small mammals, and terrestrial invertebrates. An existing systematic random sampling design for Alaska (Handel 2003) was adopted to ensure widespread and unbiased coverage of the refuge. During 2004 to 2020, refuge personnel will visit approximately 60 plots, each consisting of 12 sampling points. This sampling design will allow statistical inference to unvisited areas comprised of similar habitat and physiography.

Point count methods for birds follow the Alaska Landbird Monitoring Survey (ALMS) protocol (Handel and Cady 2004). Vegetation and habitat methods were derived from both ALMS and the Denali National Park and Preserve Inventory Program (Roland et al. 2003). Collections of small mammal and insects follow guidelines provided by the University of Alaska Fairbanks Museum. Insects are collected from only one sampling point per plot. Trees are aged via increment borings or tree cross-sections at each sampling point. Three plots were surveyed in 2004 as a pilot effort to test methods. It was determined that a plot could be surveyed in 3 - 4 days, and at least three plots could be visited per year given current staffing levels.

Figure 6. The Integrated Terrestrial Inventory Program will catalog the diversity of breeding birds, habitats, small mammals, and terrestrial invertebrates found on the refuge.

Panel Recommendations: Integrated Terrestrial Inventory Program

High Priority

- Kanuti NWR should inventory fish, wildlife, and plants to document their distribution and abundance and develop hypotheses on the potential factors influencing them. The refuge should collaborate with and support the University of Alaska Fairbanks Museum to validate the identification of specimens, prioritize taxonomic groups to inventory, and develop specific field protocols. A cooperative agreement or research work order with the University of Alaska could provide an annual stipend to the museum to identify and archive refuge collections.

8. Subsistence

One of the establishing purposes of Kanuti NWR under ANILCA is to provide, in a manner consistent with other establishing purposes, the opportunity for continued subsistence uses by local residents. The 208 residents of the four communities (Alatna, Allakaket, Evansville, and

Bettles) immediately adjacent to the refuge have a long history of harvesting the region's natural resources for subsistence purposes and they continue to hunt, fish, trap, pick berries, gather birch bark, and cut house logs on the refuge. Annual subsistence harvest surveys of moose, caribou, bears, and fish have been conducted by the Alaska Department of Fish and Game. The Service has also periodically conducted harvest surveys of migratory birds and other wildlife resources.

Harvest of wildlife by people outside of these communities has been light; however, hunting pressure may increase, particularly as restrictions such as drawing permits are established in other areas. Competition for resources between local and non-local hunters and as well as reduction of ungulate populations by predators are concerns commonly voiced by rural residents. Predator control has been proposed as a means to increase moose numbers. Kanuti NWR must balance mandates to provide for subsistence opportunities, maintain ecological integrity, and provide for wildlife-dependent public use, including hunting.

Panel Recommendations: Subsistence

High Priority

- Kanuti NWR staff should collaborate with subsistence specialists from the Alaska Department of Fish and Game, Migratory Bird Management, and other agencies to design and implement surveys to record and archive traditional ecological knowledge about the refuge.

Summary

The findings and recommendations of the Kanuti NWR biological program review panel are intended as guidance for refuge staff to develop a long term ecological inventory and monitoring plan, and a collaborative research program. These recommendations are currently being incorporated into the revised Kanuti NWR Comprehensive Conservation Plan.

The biological program review panel recommended that Kanuti NWR biological staff design and implement studies that will provide needed baseline data on the distribution and abundance of select fish and wildlife species, including aquatic and terrestrial invertebrates. As a result of time and budget constraints, refuge biologists should seek research partners and fund graduate research to address additional issues, concerns and questions.

Updates and revisions of the draft ecological characterization model (Saperstein 2002: fig. 9) will allow the refuge to identify studies to be included in the Long Term Ecological Inventory and Monitoring program versus those best addressed by collaborative research. The model will allow Kanuti NWR to identify and prioritize investigations on hydrology, soils, and climate to better understand and explain factors that influence the abundance, distribution, and interrelationships of biological populations.

Data management is critical to the success of the refuge biological program. Kanuti NWR staff recently identified historical and current data sets in notebooks or stored in out-dated or unsupported spreadsheet or database software (Appendix B). Refuge staff should design and implement a database management plan to ensure such data are entered, archived, analyzed and reported in Service publications, peer-reviewed journals, and/or presented at professional conferences or symposia. Data collected from ongoing projects should be updated and maintained to facilitate analysis and publication. Proposed inventory, monitoring, and research projects conducted by refuge personnel and cooperators must include adequate funding to manage and maintain data sets. Project databases should include metadata (i.e., information on the type and format of data) to ensure a clear understanding of study design and sampling protocol. By addressing the issue of database management, Kanuti NWR will avoid the potential loss of historical and current scientific information due to personnel turnover, or the replacement or failure of computer hardware/software.

To provide an annual source of funding for research, the refuge should develop a Refuge Operation Needs (RONS) proposal. The proposal budget should include expected costs for at least one graduate student and include an annual stipend, logistic and field study expenses, thesis preparation, professional meeting travel costs, and publication page charges. An expected annual research budget will allow the refuge to address research priorities identified from the strategic plan while using other base funds to maintain the Long Term Ecological Inventory and Monitoring Program.

Kanuti NWR should increase efforts to distribute findings of inventory, monitoring, and research studies to the public and the research community. Current and proposed inventory, monitoring, and research studies and requests for proposals should be posted on the internet. Refuge personnel are encouraged to contact research institutes, field stations, and universities to present findings and seek collaboration.

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APPENDIX A

Appendix A. Panel rankings for current and proposed studies on Kanuti NWR. Rank scores range from 1-3. Studies were classified as high priority (mean rank $\geq$2.4), medium (mean rank $\geq$1.7 < 2.4) and low (<1.7). Agencies or organizations in parentheses indicate current or potential collaborators.

Topic	Mean Rank
Moose – conduct annual composition surveys to assess moose population (ADF&G, BLM)	2.867
Fire ecology – map the spatial and temporal fire pattern for Kanuti NWR	2.867
Human dimensions – monitor human use of refuge and its resources	2.867
Moose – estimate refuge population via intensive surveys every 5 years (ADF&G, BLM, NPS)	2.800
Migratory birds – monitor populations and distributions of mid-continent greater white-fronted geese via supporting aerial molt surveys (MBM)	2.800
Fisheries – design and implement surveys to determine the seasonal distribution of whitefish and northern pike (FFWFO)	2.800
Fisheries – identify and map the spatial distribution of spawning and wintering areas for priority species of anadromous and resident fish (FFWO)	2.733
Migratory birds – continue Off Road Point Count Surveys to monitor composition, distribution, habitat and relative abundance (USGS, BPIF)	2.667
Hydrology – construct hydrological model for Kanuti NWR and collect data required for model development (e.g., precipitation, drainage, elevation). (UAF-IWR, USFWS-WRD, USGS)	2.667
Migratory birds – continue Breeding Bird Surveys to monitor composition, distribution, relative abundance (MBM)	2.600
Beaver – Conduct aerial beaver cache surveys as an index to the refuge beaver population	2.533
Subsistence – conduct harvest surveys for fish and waterfowl (ADF&G, FFWO, BLM)	2.533
Environmental monitoring – continue monitoring monthly snow depth (n = 6 markers) and density (n = 2 markers) surveys in cooperation with NRCS	2.533
Vegetation – revise the refuge land cover map, completed in 2001 using 1999 Landsat imagery, as needed to reflect changes in vegetation	2.400
Environmental monitoring – examine, and if feasible, monitor phenology of physical events (e.g., ice break-up of the Kanuti river, snow melt) (USGS, UAF)	2.400
Vegetation – examine and implement methods (e.g., NDVI) to record vegetation green-up	2.400
Subsistence – conduct workshop with AMBCC, ADF&G, NPS, and BLM to standardize subsistence harvest surveys	2.400

Migratory birds – conduct breeding pair surveys to monitor distribution and abundance of waterbirds (see Platte 1999; MBM)	2.333
Vegetation – document and describe plant communities atypical on Kanuti (e.g., Kanuti River Canyon and along the Kanuti-Kilolitna River) and investigate other potential sites	2.333
Migratory birds – assist with banding of mid-continent greater white-fronted geese (MBM)	2.286
Amphibians – support regional and national survey of malformed frogs	2.286
Hydrology – design and implement an aquatic inventory study to examine select biological and physical characteristics of wetlands and streams (NPS, UAF, USGS, USFWS Fairbanks Fish and Wildlife Field Office)	2.286
Migratory birds – support studies on species of concern for land birds (BPIF)	2.200
Subsistence – collect traditional ecological knowledge on wildlife and subsistence use	2.200
Subsistence – inventory and map cultural and paleontological sites	2.167
Snowshoe hares – design and implement surveys to index population (UAF, NPS, BLM, Kluane NPP)	2.143
Migratory birds – assist with aerial swan surveys, conducted at 5-year intervals (MBM)	2.143
Inventory and Monitoring Plan – design and implement a collection-based inventory for plants, invertebrates and vertebrates (UAF)	2.133
Caribou – assess spatial and temporal use of the of the Ray Mountain Caribou Herd on Kanuti NWR (ADF&G, USGS, UAF, BLM)	2.077
Hydrology – examine existing methods or develop new methods to map annual flooding	2.077
Hydrology – based upon results of the aquatic inventory study (see above), design and implement a long-term study to monitor biological and physical characteristics of wetlands and streams (NPS, UAF, USGS, USFWS Fairbanks Fish and Wildlife Field Office)	2.067
Fire – continue monitoring small mammal species composition on permanent trapping grids established in a 1990 burn	2.067
Environmental monitoring – expand use of remote-automated weather stations and data loggers to record weather conditions	2.067
Inventory and Monitoring Plan – research rapid ecological assessment techniques and develop protocols to consistently record biological/environmental data in conjunction with other activities	2.067
Wolves – conduct aerial surveys to estimate population of wolves at 3-year intervals (ADF&G)	2.000
Environmental monitoring – examine existing air and water quality monitoring studies by EPA, NPS, and USGS to determine the need for Kanuti NWR to develop its own monitoring program.	2.000
General ecological inventory – design and update a database for incidental observations	2.000
Subsistence – design and implement a database for traditional ecological knowledge	2.000
Furbearers – design and implement an aerial track survey to index abundance and distribution of furbearers (ADF&G, NPS, USGS)	1.933
Fisheries – implement an otolith study to examine Sr levels to document species and age distribution of whitefish (FFWO)	1.933

Moose – continue winter transect surveys to map moose concentration areas in periods of variable snow conditions	1.929
Migratory birds – support studies to address wetland-dependent avian species of concern	1.923
Raptors – inventory and map active raptor nests on Kanuti NWR	1.867
Migratory birds – design and implement a study to examine the relative abundance and distribution of shorebirds (MBM)	1.867
Migratory birds – examine methods to map landbird distribution and associated habitats	1.800
Fire – continue monitoring vegetation and fire variables along eight permanent transects established within a 1990 burn	1.800
Environmental monitoring – support contaminant assessments and special studies (USFWS-FFWO)	1.786
Hydrology – design and implement an ecological monitoring study of spring flooding (USGS, UAF, ADF&G, NPS, BLM)	1.733
Fire – design and implement a long-term, post-fire monitoring study of abundance and species richness of landbirds	1.714
Moose – design and implement spring calving surveys (ADF&G, USGS-ASC)	1.679
Amphibians – identify and map ponds, count egg masses, and estimate number of malformed vs. normal individuals (USFWS)	1.643
Hydrology – record incidental observations of wildlife in stream and wetland habitats during long-term monitoring study	1.615
Beaver – design and implement a population density-habitat study (UAF, ADF&G, USGS)	1.600
Moose – design and implement a habitat selection and seasonal movement study (ADF&G, USGS, UAF)	1.600
Bears – assess survey methods to monitor populations of black and brown bears on Kanuti NWR (ADF&G, USGS, UAF)	1.600
Bears – record incidental observations of bears, kill sites, and dens	1.600
Environmental monitoring – evaluate potential mercury contamination at abandoned gold mining sites	1.600
Migratory birds – design and implement methods to examine distribution and breeding status of gulls, corvids, raptors (MBM)	1.533
Fisheries – conduct opportunistic sampling of lakes and streams to document occurrence of fish species	1.533
Moose – design and implement a long-term study to examine quantity, quality, and availability of forage species	1.467
Beaver – develop a correction factor to estimate the number of number of individuals associated with a cache	1.333
Vegetation – design and implement a protocol to record annual plant phenology	1.286
Hydrology – examine physical and chemical properties of water for wetlands with beaver versus without beaver	1.200
Furbearers – design a trapper survey to sample marten, wolves, lynx, otter, and beaver for morphology and reproductive status	1.200
Snowshoe hares – assess methods and feasibility of browse surveys or pellet counts as a population index	1.133

Physical factors – inventory soil invertebrates	1.133
Small mammals – conduct opportunistic collection-based inventory of small mammals in different habitats	1.067
Wolves – collect wolf and bear scats incidental to other field work and conduct analyses of foods	1.000

APPENDIX B

Appendix B. Historical and current research and management projects conducted, or supported, by Kanuti National Wildlife Refuge that require data entry, analysis, and/or write-up.

Furbearer Carcass Collection

Principal Investigator: Kanuti NWR
Study Period: 1992-1998
Objectives: Purchase carcasses from trappers to allow Kanuti NWR staff to: (a) determine physical condition of refuge furbearers and (b) collect traditional ecological knowledge from trappers using the refuge.
Data Issues: Kanuti NWR purchased carcasses from trappers and performed necropsies. A subsample of teeth was sent to a lab for aging. Data collected in 1992-1993 were partially summarized in the 1994 refuge annual narrative. Data sheets and notes for the entire project were located in 2001 and information remains on data sheets, hand-written notes, and in a 1996 progress report. An Access database was also developed; however, data have not been entered.
Data Treatment(s):

a) Review database design
b) Enter data into database
c) Prepare final report

Map Traplines on Kanuti NWR

Principal Investigator: Kanuti NWR
Study Period: 1992-1997
Objectives: Document trapping activity on Kanuti NWR
Data Issues: Winter traplines were mapped based on aerial observations, and inquiries in the Native villages. Data are currently hand-drawn on 1:250,000 USGS maps.
Data Treatment(s):

a) Search historical files for pre-1992 trapline locations
b) Develop an Arc View project of all trapline locations
c) Prepare a final report

Fire History Map

Principal Investigator**:** Kanuti NWR
Objectives:

1. Obtain data from the Alaska Fire database on tree ages in areas that did not burn between 1950- present
2. Obtain ages of fire-scarred trees at the edges of known-age burns
3. Assess habitat and fuels in burns and at tree age collection sites.

Data Issues: This project was initiated in 1999 with the intention of sampling on a regular basis until fire history was reconstructed for the refuge. Fourteen sites were visited in 1999. A

narrative trip report is available for the project, but it was drafted before samples were analyzed to obtain tree ages and did not include analysis of habitat and fuels data. Habitat and fuels data remain on data sheets and tree age data are hand-written on notebook paper.
Data Treatment(s):

a) Develop and populate a database for tree age and habitat data
b) Prepare final report for data collected in 1999

Diversity and Relative Abundance of Aquatic Invertebrates

Principal Investigator**:** Kanuti NWR
Study Period: 1999-2001
Objectives: Collect baseline data on the diversity and relative abundance of aquatic invertebrates
Data Issues: Lakes were subjectively selected and sampled for aquatic invertebrates in fall 1999-2000 and in spring 2001, following a protocol developed under contract for Kanuti NWR. Trip reports were written and invertebrates were identified to lowest possible taxa. The refuge has a contract with to analyze and discuss results of this project (due 31 July 2005).
Data Treatment(s): Develop a final report.

Fire Influences on Lakes in the Boreal Forest

Principal Investigator: Kanuti NWR, U.S. Fish and Wildlife Service, Regional Office
Study Period: 1991-1998
Objectives: To assess the long-term effect of fires on lake chemistry
Data Issues: A fire in 1991 allowed the refuge the opportunity to compare water quality of lakes with shorelines that burned and those not impacted by the fire. Kanuti NWR staff collected water samples once (1995, 1998) or twice (1991-93) during the growing season The former Regional Refuge Biologist, Dr. Patricia Heglund (U.S. Geological Survey, LaCrosse Field Station) developed a draft report in July 2002.
Data Treatment: An introduction, literature review and response to review comments are needed to finalize the report.

Late winter distribution of moose on Kanuti National Wildlife Refuge

Principal Investigator: Kanuti NWR
Study Period: 1998-2001
Objectives:

1. Assess distribution of moose on Kanuti NWR from late February to early March
2. Develop habitat selection models based on winter moose distribution, landcover, slope and aspect, fire history, and distance to water.

Data Issues: Moose locations were recorded by Kanuti NWR staff during aerial surveys and a draft trip report was never finalized. Kanuti NWR and the Service's Regional Office prepared GIS data WEST, Inc., is currently developing habitat selection models. .
Data Treatment(s): Obtain results from WEST, Inc. and complete final report.

Flora and Insects of the Kanuti River Canyon

Principal Investigator: Kanuti NWR
Study Period: 2003
Objectives: Collect plant and terrestrial insect samples in bluff and riparian habitats
Data Issues: Plants and terrestrial insects were collected in the Kanuti River Canyon. Plants were sent to the University of Alaska Fairbanks Museum for verification. Insect specimens were identified to the lowest possible taxa.
Data Treatment(s): Prepare final report.

Assessing Long Term Drying of Wetlands

Principal Investigator: Kanuti NWR
Study Period: 2000-2001
Objectives:

1. Monitor potential changes in submergent, emergent, and shoreline vegetative communities;
2. Monitor potential change in wetland bathymetry;
3. Collect traditional ecological knowledge from Native village residents on potential changes in wetlands.

Data Issues: Vegetation transects were established from the lake edge to upland vegetation at two lakes and plot locations were marked with rebar. Water depths were recorded via an electronic depth finder A third lake was also sampled; however, vegetation transects were not marked. A draft report that summarizes Village meetings must be completed. Pre-existing aerial photography was collected for the three lakes, and new photography was acquired by taken under contract. Ducks Unlimited provided a report about the uses and limitations of satellite imagery.
Data Treatment(s): Prepare final report.

Develop a GIS-compatible Atlas of Bird Observations for Kanuti NWR

Principal Investigators: Kanuti NWR, Migratory Bird Management (MBM), U.S. Geological Survey (USGS)
Study Period: 1983-current
Objectives: Project-specific (see below)
Data Issues: Historical observations of the avifauna on Kanuti Refuge are derived from multiple projects (e.g., waterfowl surveys, float surveys, point counts); exist in various media (e.g., original dataforms, map notations, type-written reports, annual narratives, spreadsheets, databases) and in various locations (e.g., general and personnel files, collaborating agencies). Many data are not in a readily accessible format for even such simple purposes as compiling a refuge bird list or describing occurrence, distribution, and/or abundance. Refuge staff has contributed data to larger collaborative efforts, including monitoring birds on statewide or continental scales. Additionally, refuge bird data have been collected by partners (e.g., Migratory Bird Management) for large-scale efforts. These data have generally (and necessarily) been analyzed and reported on scales beyond Kanuti NWR. Applicability and usefulness of Kanuti-specific data are lost in the greater analysis and reporting.
Data Treatment(s):

a) Begin data mining of historical observations from major refuge-specific bird programs
b) Acquire bird data collected on/near Kanuti NWR from collaborators (e.g., MBM)
c) Develop an ArcView-compatible Access database for input, storage, and retrieval of historical bird observations. Ensure that appropriate fields are employed (e.g., location, date, project, observer)
d) Produce reports of Kanuti NWR-specific data from major collaborative efforts (e.g., where Kanuti-specific data are subsumed and reported as part of larger strata). Because the scales of some of these collaborative projects were designed to address regional, state-wide or national objectives, the subset of Kanuti NWR-specific data may not permit similar statistical analyses and interpretations to those reported in larger-scaled reports. However, summary statistics might provide meaningful data for the refuge to design and implement pilot projects to address refuge-specific objectives.

Major projects whose data should be mined for atlas and/or reports:

1) Kanuti NWR-specific waterfowl surveys (1983-1989): includes primarily plot- and/or waterbody-based production for dabblers and divers
2) MBM waterfowl production surveys (1990-1993): random plot-based, with Kanuti NWR-based data subsumed under larger "Koyukuk" stratum (i.e., also includes data from Koyukuk and Nowitna refuge)
3) MBM Swan surveys (1985, 1990, 1995, 2000, 2005, etc.): again, Kanuti NWR data lumped in the larger "Koyukuk" stratum
4) MBM North American Waterfowl Breeding Pair Survey: (annual since 1958; includes only 2 transects (4 segments) for Kanuti NWR
5) MBM Expanded Breeding Pair Survey (1997): (Kanuti NWR-specific data are subsumed again under larger "Koyukuk" stratum; similar survey to #4 above, but with much more intensive effort (i.e., more transects covering all significant wetland habitats)

6) Continental Breeding Bird Survey (1993-1995, 1998-present): includes data from 1-2 routes (i.e., Kanuti Canyon BBS, Koyukuk River BBS [discontinued in 2000], Kanuti Lake BBS [initiated in 2004])
7) Alaska Off-road Point Count program (USGS): 3-5 routes run annually 1993-1995, 1998-2002
8) Alaska Landbird Monitoring Survey (USGS): 3 routes run 2003, 1 in 2005
9) Kanuti Integrated Terrestrial Inventory: 3 plots in 2004-05
10) General reconnaissance float surveys: (e.g., Kanuti River, Kanuti Kilolitna River)
11) Greater white-fronted goose surveys: includes both production surveys by watercraft (1995-2002), as well as aerial molt surveys (2001-03; annually resuming in 2006)
12) Raptor float surveys of Kanuti Canyon: 1998-2000

APPENDIX C

Appendix C. Written comments on the Kanuti National Wildlife Refuge 2002 Biological Program Review Briefing Document.

Reviewer 1. Tom Paragi, Wildlife Biologist, Alaska Department of Fish and Game, Fairbanks, Alaska
Glenn Stout, Area Biologist, Alaska Department of Fish and Game, Galena, Alaska

I read over the review package you sent and came up with some comments and recommendations. I ran them by Glenn, and he agreed that they might be useful for you or Pat Heglund to read before the review. The attached image shows the fire protection levels currently on the refuge. Overall you did a thorough job of compiling a lot of information in a well organized, highly readable fashion--kudos!

Talking points /questions

1) Is use of fire by Alaska Natives prior to European settlement of the upper Koyukuk beginning around 1900 part of "substantial human related changes to landscapes" (p. 2)?

2) Congressman Young has proposed to privatize management of the Koyukuk and Kanuti NWRs with Alaska Native corporations. What are implications to the biological program of such privatization to management-related issues, specifically (a) fire policy and (b) human use (harvest monitoring, cabin construction, access by non-local consumptive users)?

3) List some specific ecological features or processes with respect to "better understanding of ecological processes" (p. 4) that can be talking points or draft goals of the biological program (see also comment 6).

4) The latest discussion from some Canadian researchers (Johnson et al. 2001, Conservation Biology 15:1554-1557) suggests that fire suppression in boreal regions leads to increased risk of fire spread because of continuity between ground and crown fuels, not a buildup of fuels (item 3.5, p. 9).

5) Which species of resident fish are being considered for commercial harvest (pp. 15-16)?

6) "displaced [non-local?] hunters will eventually move upriver" (p. 22)--Given that the permit system on the lower Koyukuk is lowering competition from non-local hunters, why is this still a concern? I can't believe that boat hunters coming from the Haul Road or Nenana will continue past Huslia to the Kanuti Refuge, particularly since the moose density is relatively low there compared to the lower Koyukuk.

7) The strength of Kanuti's scientific contribution to resource management lies with unique geographic scenarios, such as population declines in mid-continent white-fronted geese that nest on Interior refuges. The goals and objectives listed for some species in Section 8 (beavers, mammalian carnivores) need to be tied to a specific problem or desired end result because consumptive use of these species is not likely to pose conservation threats on Kanuti or

elsewhere in the Interior ecosystem in the near future. The objectives listed would be useful as response parameters in manipulative studies (e.g., different harvest intensity or fire effects among areas), but the value of documenting them alone is questionable for the logistical effort and cost and may be outside the "applied research" realm of NWR staff. As you allude to in a couple sections, working with other organizations (UAF, USGS, NRCS, ADF&G, TCC) to determine geographic data needs and optimal contribution outside the core value of NWRs (migratory birds) is a good approach.

Recommendations in decreasing order of importance

1) Headwaters of refuge tributaries crossing the TAPS corridor are potential sources of primarily petroleum contamination and secondarily sewage and road sediment. Baseline data on metal and petroleum contamination in fish, amphibians, semi-aquatic mammals (particularly mink and river otter), and nestlings of piscivorous raptors (bald eagles, ospreys) are lacking to assess effects of a spill on subsistence foods, wildlife population parameters, contaminant transport through the food web. Lack of baseline data on contaminants in most wildlife species and on wildlife population parameters was a major detraction in detecting effects of the Exxon Valdez Oil Spill in Prince William Sound. Baseline data on contaminants in riparian species within the eastern border of the refuge is justified broadly for several species (items 5.4.B, 6.1, 6.2, 6.2.A), such as mentioned above, and specifically for wood frogs (item 5.1.A). Continued use of the aging pipeline for oil transport ranks this as a high priority.

2) A primary value of NWRs is habitat for migratory birds, and understanding population trends relative to habitat changes at the landscape or ecosystem scale is a primary mission unique to FWS. As a complement to the previous recommendation (baseline population parameters on selected species); therefore, the refuge should work with Migratory Bird Management to identify avian species on which they could make the greatest scientific contribution for the geographic area. Aside from standardized surveys of occurrence and abundance, the greatest contribution by refuge staff might not be study of rare species (a task better undertaken by BRD on a much larger scale with specialists) but instead studies of fitness traits for more common species on the refuge that may be relatively rare elsewhere in the Interior (e.g., species groups listed under 8.5).

3) Assessing the value of burns to moose habitat and population dynamics is important because of societal differences over intensive management of ungulates (6.3) and fire management policies. Documenting post-fire regeneration of vegetative communities with an emphasis on deciduous woody species at the landscape scale (remote sensing for typing) and stand scale (stem density and biomass estimation during field checks of typing classification) is important to evaluate fire effects and fire management policy (8.2.A). Associated work begun by refuge staff in recent years to document moose distribution and range use relative to snow depth among years is equally important to continue. Assessment of moose productivity (calving and percent twinning) in concert with winter conditions and proximity to burns is also useful if adequate visual samples can be obtained.

Although it would be desirable to assess the effect of Modified suppression on the fire regime of the northern half of the refuge relative to Limited suppression on the southern half (see attached figure), the scale of measurement needed is far beyond the boundaries of the refuge (note for

8.10, objective 4). Whenever possible, the refuge should support field work on documenting fire history and fire effects carried out by Alaska Fire Service or academic researchers.

4) Headwaters of some refuge tributaries contain historical mining activity, and mineral deposits on adjacent lands have potential for mining effluent (mercury, arsenic, sediment) to contaminate refuge waters. Baseline data on metal contamination in biota and sediment bedload in tributaries would permit assessment of future effects of placer mining on refuge biota (8.13). This is justified for several species (5.4.A, 6.5), such as mentioned above, and specifically for wood frogs (item 5.1.A).

5) Mature forest on the levees of lowland streams and rivers of the Kanuti River floodplain (within Limited suppression) may provide a natural control for "old growth" forest (5.3.A) relative to harvest of floodplain forest in the Tanana Valley. Habitat selection and habitat-fitness relationships for selected game and non-game species can be documented in the context of a minimal subsistence harvest of timber and a largely natural fire regime on the southern half of the Kanuti Refuge. Priority would be for stands of white spruce or white spruce-balsam poplar of commercial saw log volume, which exist along sections of the Kanuti River and possibly some of its major tributaries. Likely partners would be the ADF&G nongame and habitat programs in the Division of Wildlife Conservation.

6) Inventory of spawning and overwintering sites for resident and anadromous fish stocks, particularly in the eastern refuge tributaries, is important relative to potential contamination effects from the TAPS. Inventory should be coordinated with ADF&G Habitat Division to ensure timely inclusion of data in the cataloging system for fish habitat that is progressively becoming digital.

7) This final recommendation is a management issue that would require caribou range inventory. Some scientists predict that fire return interval will become shorter with climate warming. With respect to caribou winter range, you might define the area that you consider to be good quality range and then stipulate an acceptable rate of replacement by fire for purposes of setting fire management policy on that area (e.g., the wetland complex in center of refuge). For example, allow no more than 5% of the area to burn per decade, which gives you complete range replacement (turnover by fire) in 200 years. The work by Bruce Dale and Bill Collins in the Fortymile area suggests that you need 60 years of regrowth to start producing acceptable lichen biomass. Assuming you start with good quality range (=>60 years old) over the entire area, allowing <=5% of the range to burn per decade without spatial overlap (reburn of young range) would maintain =>70% of the range in the 60-200 year age class over the long run. This way fire can rejuvenate the range slowly on a rotating spatial basis. If you shoot over 5% in an extreme fire year, you can apply greater suppression vigilance in the next decade to try and get back on schedule within the defined area. (I don't think we want to take the opposite approach and use prescribed fire to "catch up" if <5% of the area burns because lichens are still healthy out to 300 years.) At least this approach provides an objective decision framework from which to start and see how it works in the real world of political decisions.

Reviewer 2. Richard Lanctot, Alaska Shorebird Coordinator
U.S. Fish and Wildlife Service, Migratory Bird Management
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Pat Heglund suggested that biologists from the Migratory Bird Management branch review the Kanuti NWR 2002 Biological Review Briefing Packet. As the new shorebird coordinator for Region 7 (replacing Brad Andres), I thought I could provide some helpful suggestions for your program. I recognize that Kanuti has a small staff and that you are already conducting many biological tasks. As such, I have tried to come up with suggestions that might fit in to your existing program.

First, I wanted to mention that the U.S. shorebird monitoring committee is trying to implement a breeding shorebird-monitoring program throughout Alaska and Canada. This program, officially titled PRISM, for the Program for Regional and International Shorebird Monitoring, aims to provide reliable information on the distribution, abundance, and trends in population size for shorebirds. One of the four strategies being used to do this is to survey breeding shorebirds in arctic and boreal regions of Canada and the Alaska. Migratory Bird Management, in collaboration with Dr. Jon Bart of the U.S. Geological Survey, has been surveying shorebirds in the Arctic for the past four years (i.e., National Petroleum Reserve-Alaska, Kuparuk and Prudhoe Bay Oil Field regions, and as of this spring, the Arctic NWR). Staff from the Yukon Delta NWR have also been surveying shorebirds during the past few years. This past spring, three other refuges initiated pilot studies to investigate the feasibility of surveying shorebirds on their refuges. These include the Alaska Maritimes NWR, the Alaska Peninsula NWR, and Selawik NWR. A lower level of effort was also conducted with staff at Tetlin NWR, investigating monitoring boreal breeding shorebirds.

Unfortunately, surveying shorebirds in boreal regions is difficult to do and methodologies are only now being explored. Vicky Johnson of the Canadian Wildlife Service is heading up a committee to work on this problem. She conducted surveys from helicopters this spring, with the assistance of Ducks Unlimited, and found that method had some promise. Given the habitat conditions on Kanuti, you probably would be most interested in this approach.

The eventual goal of PRISM is to get all of the refuges, and parks and preserves, within Alaska to conduct surveys so that a final population estimate for the different shorebird species can be established for North America. I realize this is an ambitious but not impossible goal. Given that refuge funds are spread thin, it is imperative that we try to incorporate any shorebird surveys, at least at the beginning, into pre-existing surveys. As shorebird monitoring becomes more established, I hope to be able to generate and thereby provide funds to implement this program.

A review of the biological inventories being conducted on Kanuti NWR suggested several opportunities where shorebird diversity and abundance could be documented. The first might include some of the aerial surveys being conducted for waterfowl and geese. If these surveys are flown low enough and slow enough, it is possible to document some of the larger shorebirds such as Whimbrels and Wandering Tattlers. Brian McCaffery and Chris Harwood have counted shorebirds while flying harlequin duck surveys along streams on the Yukon Delta NWR. A second possibility is to count shorebirds during the canoe survey on the Kanuti River. Here some

of the species using the river corridor might be inventoried (e.g., semipalmated plover, solitary sandpiper, wandering tattler). A third possibility includes the BBS and ORPC surveys. These surveys, depending on the habitat, might work well for any of the other 19 breeding species observed on Kanuti.

I commend you for making documenting seasonal shorebird use of Kanuti NWR as one of the four goals in the Bird Ecology section of your review. I would suggest, however, that you not limit your priorities to Whimbrels, as two other species known to breed on the refuge have an equally high priority status in the Alaska Shorebird Conservation Plan (i.e., Wandering Tattler and Surfbird). Unfortunately, these three species use very different habitat making survey implementation more difficult. In addition, there are twelve species that occur on the refuge that are ranked only one step lower. Indeed, I was impressed to see the diversity of shorebirds that use the refuge (19 breeders and 4 rarely seen species).

Given that there were no past or present studies conducted on the refuge for shorebirds, I would be happy to work with you in developing a more comprehensive shorebird-monitoring program. This may be an especially good time to do so, given the strong interest in shorebirds by other refuge staff and the nation as a whole. We are planning a meeting with refuge staff to discuss the results (both methodological and empirical) of last summer's surveys later this fall. I would encourage you to attend this meeting if possible. I will e-mail you with a time and place when this becomes more established.

Thank you for giving me the opportunity to review your program, and I hope we can work more closely together in the future.

Reviewer 3. Layne G. Adams, Research Wildlife Biologist
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Here are my comments regarding your 2002 Biological Review. I wish I could have attended the actual review, but hope that these comments are useful in finalizing the biological program for the refuge. I'd like to commend Lisa Saperstein for providing a useful briefing packet that provided the appropriate amount of background information and a comprehensive framework for the biological program to focus the review.

After digesting the briefing materials, I get the impression that the primary objective of the biological program is to institute a broad ecological monitoring effort, largely because the current, perceived issues are diffuse and low intensity. In many ways, this is a more difficult task than designing a monitoring program that addresses existing, major threats. You are faced with identifying the future issues or concerns that may arise and developing a broad program of monitoring with a long-term perspective, rather than attacking identified information needs. Particular components of a good monitoring program may be appear relatively unimportant right now, but can pay off greatly in the long run.

Although reviewers can provide substantial assistance in evaluating particular monitoring tasks or objectives, you have the difficult job of using that input to arrive at a final monitoring program that you can truly afford over the long-term. A key trap in developing such programs is trying to do too much, in order to cover the gamut of topics, and ending up doing a less than adequate job on all the tasks. If a particular information need is important, then it should receive adequate attention and funding, even if that means other lower priority needs have to be cut altogether from the program.

Here are specific comments on some of the topics within your draft biological program. I have restricted my comments to those species that I have some familiarity with.

Beaver:

Although I am certainly not current on the beaver literature, I recognize the major role that beaver can play in Interior Alaska ecosystems. Given a long-term focus of your biological program, the highest priority for beaver should be to establish a reasonable approach to monitoring their distribution and relative abundance (8.1A, Obj 1). I think you can be satisfied with the number of observed active caches as an index to beaver abundance without getting too concerned over missing some beaver that den in banks or estimating the number of beaver associated with caches (8.1A, Obj. 2). It seems like the current moose survey methodologies could be adapted to estimating the number of active beaver caches throughout the refuge. Repeatedly surveying the same sample units each year could improve your ability to detect changes among years. Further, monitoring the effects of beaver on the landscape (e.g., the extent of water impounded by beaver within sample units) may also be of value. Once the methodologies are worked out it, you may be able to get by with conducting surveys on a 3-5 year schedule to detect long-term trends, but annual surveys initially would provide insight to the amount of variation among years and guide decisions on the ultimate monitoring schedule.

Moose:

Moose seem to be an important and high profile issue for the refuge, and therefore deserve adequate attention in the monitoring program you ultimately design. Rather than intensive surveys every 5 years with lower intensity efforts in between (8.2A, Obj 1 and 2), consider conducting full surveys each year. Given the low density of moose on the refuge, quite a bit of effort must be expended to even collect adequate sex and age data each year, so I doubt the differences in cost would be that great. Further, with variation in weather and snow conditions, it is unlikely you'll be able to pull off annual surveys even if you try.

Because of the importance of moose, a well-designed browse monitoring component (8.2A, Obj 3) could be a useful part of a long-term program, providing an assessment of habitat condition that would dovetail with other efforts to monitor fire regime and vegetational changes in general. It is important at the outset that you design a solid program with specific objectives, that is logistically feasible. I don't think that the winter distribution surveys (8.2A, Obj 4) are of much value, however.

A radio telemetry study (8.2A, Obj 5) could provide a broad suite of useful information on the Kanuti moose population well beyond investigating seasonal distribution and movements. If properly designed and conducted, it would provide an assessment of the nutritional condition of moose (body size, rump fat depth via ultrasound, 10-month-old calf weights, etc), and unbiased measures of productivity and survival patterns, in addition to seasonal distribution. This could be conducted with the goal of gathering baseline information on the moose population with a 3-4 year study, and following that up in the future with additional work should the need arise.

I question the value of spring calving surveys (8.2A, Ob. 6). Although they are widely conducted, the information gained in biased and greatly affected by the timing and intensity of the surveys. The number of cows with calves and the proportion of twins are changing on a daily basis, from calf production and predation, during the period of time these surveys are conducted, so it is very unclear what the results mean.

Caribou:

Caribou use of the refuge is sporadic at best, so I don't see the need for the work described (8.2B, Obj. 1 and 2).

Predators:

As with moose, the vagaries of getting decent conditions to conduct wolf surveys means you should plan to do them every winter, in hopes of pulling them off 1 year in 3 (8.3A, Obj 1). Any sort of effort to monitor the status and trends of a wolf population, whether methods that provide measures of precision are used or not, will only provide a general view because wolf populations are dynamic both among years and within a given season.
Carcass collections (8.3A, Obj 2) can be useful in getting a better estimate of total harvest, particularly if you pay trappers a nominal amount for providing carcasses. It will also facilitate

annual interchange with the trappers to compare notes on the status of furbearer populations. However, collecting and necropsying the carcasses can be a substantial amount of work and I think you gain little useful information from the carcasses themselves.

I see no value in opportunistically collecting scats (8.3A, Obj 3) or keeping track of incidental bear observations (8.3A, Obj 4).

Snowshoe Hares:

The methods already exist to monitor snowshoe hare cycles via pellet transects (8.4A, Obj 1). Although these methods only provide an index to hare abundance, rather than a true population estimate, they should be more than adequate for your needs. Collaborating with other organizations to answer the broader question of regional synchrony (8.4A Obj 2) is useful, but should not drive decisions about getting started with your own hare monitoring throughout the refuge. Monitoring the effects of hares on browse (8.4A, Obj 3) could easily be incorporated into the moose browse monitoring effort.

I hope you find these comments useful. If I can provide any additional help, please don't hesitate to give me a call.

Reviewer 4. Maggie MacCluskie, Network Coordinator
Central Alaska Network Inventory and Monitoring Program
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I appreciate the opportunity to review the notebook Lisa Saperstein provided for the Kanuti Biological Review on July 24-25, 2002. Though this is extremely late, I'm writing to provide a copy of my comments regarding the review as per Lisa's request. I was unable to attend to review in July, however I did read the material provided and met with Lisa on 15 July to talk about the review.

In general, I thought the material presented and projects described in the notebook were certainly thorough and, given the various pressures refuges face, appropriate. I did not spend time evaluating study design, etc. of each individual project but rather focused on whether the reasoning of need for a project was valid, and found that they were. The overriding question I was left with, and the one I spent most time talking with Lisa about, was that while the work described in the notebook was comprehensive, it seems unlikely that refuge will initiate all those projects in the next 5-10 years. Given that, what are the priorities for the refuge and how might Kanuti choose which work they will initiate first? In addition, how might the refuge consider various conceptual models of the Kanuti ecosystems to take a comprehensive approach to the work? If they could establish a unifying framework to the biological program, they would leave behind the 'grocery list' operating scheme, and move to a prioritization process/operational plan that makes ecological sense. In my opinion, that will help ensure that the program accomplishes what is intended because it will have the 'buy in' of refuge administration/personnel that is critical for sustainability. Without it (the 'buy in') it is easy to simply discard a plan when the next crises arises, etc.

It seems that the projects listed in the notebook are primarily issue driven, however I don't think that precludes a unifying framework to the biological program even if the refuge were to go through initiating a checklist of projects one-by-one. With some forethought, the projects could knit together and serve to help inform you about the refuge as a whole. Again, helping to again avoid a disjointed program that could be hard to maintain.

Those are the two primary comments I had from the notebook. I'm really excited to see Kanuti going through this review and to see places where the NPS monitoring program could partner with the refuges for monitoring and other work. It seems that it would be really short-sighted to look only within the boundaries of any refuge or park in designing these programs!

If you have any questions regarding my comments, please let me know and I'd be happy to talk with you. I'll look forward to talking with Lisa and with your replacement in Anchorage about working together in the future.

Reviewer 5. Russ Oates, Waterfowl Management Branch Chief
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Unfortunately, none of my experienced interior folks will be available for this review! So I will take a few moments and jot down some ideas based on my review of sections 7 and 8 of the briefing packet.

8.5B ...inventory and monitoring of waterbirds...

Objective 1: With assistance from MBM, Kanuti NWR will continue to conduct aerial line-transect surveys of molting white-fronted geese each year in early July. Surveys were initiated on Kanuti in 2001 and are also conducted on other interior Alaska refuges.

Response: We plan to continue to assist the refuge in the annual white-front molt survey until we determine the efficacy of this method for tracking populations. Assistance beyond that time will be determined by our (WMB
and Refuges) assessment of the value of the data.

Objective 2: Kanuti NWR will conduct an annual float survey to monitor production (e.g., total observations, young:adult ratios, age of goslings) on a segment of the Kanuti River from 27 km (17 mi) above Kanuti Lake downstream to the mouth of the Kanuti Kilolitna River. Surveys will take place in late June or early July just prior to the molt. Following several years of aerial transect surveys for geese (Objective 1), the refuge will consult with MBM to evaluate the float survey to determine the usefulness of the data and suggest improvements, if necessary.

Response: We look forward to working with Refuge staff to assess the value of this survey.

Objective 3: Kanuti NWR will assist MBM as needed with its annual efforts to band white-fronted geese or deploy satellite telemetry transmitters.

Response: WMB appreciates the excellent support we have received from the Refuge in this program.

Objective 4: Kanuti NWR will provide MBM with observers for its aerial swan survey on and adjacent to the refuge conducted at five-year intervals.

Response: We appreciate the support on this survey as well!

Objective 5: Kanuti NWR will conduct aerial expanded breeding pair surveys to document waterbird distribution following methodology used by MBM in 1997 and summarized by Platte (1999). The North American breeding pair survey conducted annually by MBM only includes two transect lines on Kanuti, which provides relatively little information about distribution on the refuge. Surveys will be conducted annually for three years, after which MBM will be consulted

for recommendations about future efforts.

Response: WMB will be glad to consult with the refuge on this project. We have discussed this with the refuge in the past but have been unable to provide aircraft and pilot support thus far. We may be able to do so in the near future. This survey has potential to be useful in the management of spring and summer subsistence harvest. We would need to know the timing of harvest (probably to the nearest week) relative to migration to
determine if locally-breeding birds or migrants are being harvested. The answer to this question would affect how the bird surveys are done. I can't recall seeing any recent subsistence harvest reports from Kanuti. Are they still done annually? What are the temporal units sampled in this survey? AMBCC and we will be glad to work with you on this. I think management of subsistence harvest of migratory birds is going to be a
significant issue on refuges that MBM and AMBCC will not be able to cover without significant assistance from refuge staffs. We have a lot of coordinating to do if we are going to make this work!

Objective 7: Because red-throated loons appear to be declining in Alaska (Gotthardt 2001, S. Hamilton, Arctic Air Alaska, pers. comm. 2001) and there is relatively little information available about them, Kanuti NWR will document the distribution and breeding status of red-throated loons during annual bird surveys on the Kanuti River and in other areas where loons may be incidentally encountered.

Response: We are in the process of developing an aerial loon survey protocol that will be available if you need it. Incidental observations will probably not be very useful for monitoring trends of a rare species such as this. The expanded breeding pair survey (Objective 5) may satisfy your needs.

Just an additional note: Is the addition of Todatonten Lake to the Refuge a dead issue? In the mid-80s it was a real treasure! I passed the book on to Kent Wohl. I'm sorry I couldn't come to this! I would have really enjoyed it.

Reviewer 6. Mark Oswood, Professor Emeritus
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This is a very nice job. The overview information provides exactly the level of information necessary to understand the rationale for the goals. Likewise, the goals seem at just the right altitude – a reach (especially at current staffing levels) but not beyond the possibility of doing. It is good to see collaboration among agencies; this seems essential when no agency has enough resources to do the job alone.

Many of the projects could make good graduate student theses. The synoptic surveys (phase 1 of Aquatic Monitoring Strategy) could be coupled with some "sexy" GIS work for some "hot" landscape ecology. Likewise, the comparative limnology of phase 2 might be approached as a string of projects: e.g., "comparison of _____ (benthic macroinvertebrates, periphyton abundance, etc.-- **pick one**) among brown water, glacial, and clear water streams. Very often, the big cost of graduate research projects is field logistics; if USFWS/NPS can provide field transportation and camps (and modest contributions to lab and publication expense), the remainder of student support can come from the university, via teaching assistantships or other stipends.

Below, I've listed specific comments, linked to page/paragraph or section of the document.

1. p.7/paragraph 5 – p. 8/paragraph 1. extent and purpose of stream gauging.

2. I presume that gauging stations will be automated – send data via satellite uplink or have long-term recorders, rather than systems that must be visited frequently for data capture/maintenance?

3. It would be nice to have gauging stations over longitudinal profiles (headwater stream to medium size river) of river systems representative of major river types (brown water, glacial, clear water). With such a set-up, you could do some "comparative hydrology" among river types (e.g., see figure 1.20 in Milner, A. M., J. G. Irons, III, and M. W. Oswood. 1997. The Alaskan landscape: an introduction for limnologists. Pages 1-44 *in* A. M. Milner and M. W. Oswood, editors. Fresh waters of Alaska: ecological syntheses. Springer-Verlag, New York.). You could also examine differences in flood routing and attenuation among river types (for an introduction see Gordon et al., 1992. Stream hydrology: an introduction for ecologists. Wiley and sons.)

4. Are there water rights issues? If so, seems odd – virtually no extraction of water and near zero human population.

5. It might be useful to gauge some otherwise similar streams, with and without beaver activity, to quantify the role of beavers in modifying hydrology and water storage and in <u>creating habitat</u>. Perhaps this could be included in your goals (8.1, pp. 28-29): the mirror image of your goals of understanding what habitat factors are associated with beaver activity. Here are a couple of useful references:

Naiman, R.J. 1984. The influence of beaver (*Castor canadensis*) on the production dynamics of aquatic insects. Verhandlungen der Internationalen Vereinigung für theoretische und angewandte Limnologie 22:1801-1810.

Naiman, R.J. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67:1254-1269.

6. pages 15-16. It seems like you really need run size data for all three species of salmon (weirs? aerial counts?). Do you have any data for escapement goals for the major runs? These would seem to be the minimal data needed to manage the subsistence takes. In addition, it would be nice to know (for representative stream systems) if sizes of runs are principally limited by: (1) number of spawners reaching spawning habitat; (2) amount/quality of spawning habitat; (3) rearing capacity (juvenile habitat).

7. I'm surprised (but no reflection on your efforts) by the lack of basic biological information, even for the "charismatic megafauna" (large mammals, raptors), let alone the "little brown jobs" (passerines and small mammals) and "small things that run the world" (invertebrates and microbes).

8. p. 19. 5.3 regarding "… species/habitat relationships …" – might the productive riparian zone (deciduous vegetation) be especially important for neotropical migrants (seems so from work at Taiga LTER – Bonanza Cr, near Fbks).

9. p. 20. List of Priority Issues (5.5 and 6.2). Is tourism on the horizon as an issue? With increased access via Haul Road, might there be pressure – or even an opportunity (a good thing?) to provide access/tours of wildlife/habitats? Increased camping opportunities?

10. p. 24. Past and present studies. I know that time and money are limiting and that many management/monitoring studies aren't suitable for science journals. Nonetheless, good data can get buried in file cabinets. Have you considered a website or CD (or both) as repository of data, photos, maps/GIS, publications/reports? I came across a very nice example of such. Last spring, I gave talk at the Kachemak Bay Science Conference, in Homer. The conference was put on by coalition of agencies and NGOs. Their CD is entitled "Kachemak Bay Ecological Characterization" citation = NOAA Coastal Services Center. NOAA/CSC/20017-DC. The CD case indicates contact as Kachemak Bay Research Reserve (907) 235-4799 coowe_walker@fishgame.state.ak.us.

11. p. 35. 8.9A macroinvertebrate species richness. Almost none of the freshwater macroinvertebrates are readily identifiable to species (usually involves rearing to adult males for insects). Suggest macroinvertebrate taxonomic richness instead of species richness; most IDs will be at genus, some at subfamily or family and a few at some higher level (class or order or even phylum).

12. p. 36. Although fairly vague/general, I think that your goal of investigating ecological consequences of spring flooding has real potential. Spring flooding can have a number of

important (but poorly known) effects: a reset mechanism for riparian habitats, “cleaning” spawning substrates (removing fines), and creating side channel/slough habitat important for rearing fish and as hot spots for invertebrates.

13. p. 37. General Ecological Inventory. Brilliant goal – constructing a way to archive and easily access all of the information that doesn’t derive from a structured study, especially observations/traditional knowledge, photos, cultural/historical information – could be one of the most useful and important contributions you could make to the future (imagine the value of such 100 years from now).

14. p. 71. Aquatic Monitoring Strategy

> I agree completely with the rationale for studying ponds and small streams. I also agree with the two stage approach suggested. The synoptic survey will be of value itself (beyond its values in establishing strata for stratified sampling).
>
> Using indices of production (biomass) and taxonomic structure seems a good route for using biota for monitoring. The approach outlined is a sort of Unrapid Bioassessment – compared to Rapid Bioassessment techniques, designed to use fairly superficial (but fast) metrics to detect gross changes in ecosystems.

15. p. 74. Pond monitoring objectives

> 1 (physical structure of ponds) is a neat idea –over long term, can use these data to detect climate change signals from good database of natural variance (“noise”). I would guess that many of these ponds are located in areas of intermittent permafrost (and have thaw bulb beneath them) so they should be sensitive indicators of climate change.
>
> 2c Genus would be good target for taxonomic level of insects and most other arthropods + some other phyla (e.g., mollusks). Other taxa will be more difficult (keys poor, requires really specialized knowledge of group, or id requires special preservation/histological techniques).
>
> 2f Using only diatoms seems a good idea to me – easier to preserve/identify than other taxa of algae + diatom community structure makes interesting comparison to paleolimnology data.

16. Objective #4. as stated, seems more like the synoptic survey (phase 1) than the point-by-point goals of phase 2.

17. Permanent photo points can capture lots of information (the human eye is very good at seeing patterns) that is difficult or expensive with formal, quantitative measurements. We’ve used such to document phenology of streams -- progression of ice (frazil and surface) and seasonality of riparian vegetation (leaf out, green-up, leaf fall).

18. Headwater stream monitoring objectives

1g. Detecting changes in benthic CPOM and FPOM will take some very intensive (= expensive) sampling. The spatial variability of benthic OM is huge (need lots of samples at each sampling date). Obviously, benthic OM changes over the year in response to discharge, riparian inputs and growth of benthic biofilm. This means that you need to sample as far into winter as possible and as early in spring as possible (not easy at remote sites) and with sufficient number of sample dates (>10 ?) to capture the seasonality.

2b. Taxonomic composition of macroinvertebrate *populations* should read macroinvertebrate *communities* (population = single species).

2c. An interesting idea to assess changes in macroinvertebrate assemblages. Will you use TWIN-SPAN or similar to define assemblages? Here are a couple of useful books on this topic:

Jongman, R.H.G., C.J.F. ter Braak, and O.F R. van Tongeren, editors. 1995. Data analysis in community and landscape ecology. Cambridge University Press, Cambridge.

Gauch, H.G., Jr. 1982. Multivariate analysis in community ecology. Cambridge University Press, Cambridge.

Most of this software (Cornell Ecology Programs) was written for mainframes and the PC versions are hideous to use. I just ran across a website for a software outfit that sells such community analysis software updated for Windows, with graphical output: http://www.pisces-conservation.com.

Reviewer 6. Karen Murphy, Regional Fire Ecologist
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Thank you for the opportunity to review the ♣briefing packet♠ materials for the biological review. I am sorry that I was unable to attend the actual review, since I imagine that many of my comments on in the written packet were clarified and discussed during the meeting. First, I want to compliment Lisa for compiling an excellent overview of the refuge and biological program. I found the packet of information to be well written and comprehensive.

There are so many interesting things happening on Kanuti refuge that I found it hard to focus my thoughts/comments strictly to the fire related aspects of the program. Instead, I found myself looking for the connections between the driving forces of flooding and fire, to the issues and objectives that were described later in the document. There seem to be several goals and objectives within the refuge♠s biological program that have the potential to be interwoven into projects that can be tied to either fire or flooding. For instance, several of the beaver/loon/wood frog objectives may be combined as part of the lake ecology and flooding studies. For fire, many of the connections are identified within the single species sections but I missed some of the important ties that are obtained from documenting fire behavior or from consideration of the fire intensity. I have provided more specific comments within the fire sections identified below.

I will be very interested in hearing the results of this review, and I look forward to working with the refuge on its fire ecology objectives. Kanuti Refuge has some unique opportunities to help us develop our understanding of fire in the boreal ecosystem and I hope that it continues to play a prominent role in projects within the refuge♠s biological program.

Specific comments:

6.2 Increased human activity along the Dalton Highway will also increase the likelihood of human-caused wildland fires adjacent to the highway. It may be useful to look at the vegetation communities that may carry fire from the highway onto the refuge (are there any large stands of black spruce connecting the highway to the refuge?). Two-thirds of the eastern border of the refuge has burned in the last 30 years so they are probably of less concern than the northern end of the eastern border. Are there areas in the NE corner of the refuge that should be protected, through suppression actions, from human-caused fires? Is there reason to change from the ♣limited♠ to ♣modified♠ category in that region?

6.2.D I didn♠t see an objective that includes monitoring for invasive plants. Is anyone doing roadside surveys along the Dalton Highway? What about on the refuge? In the absence of surveys etc. specifically designed to look for invasive plants, training field crews to recognize the most likely suite of invasive plants, and including fields for the presence or absence of these species would provide an initial step forward in monitoring.

7.2.B How widespread were the moose surveys? What are their locations relative to fire history?

8.1.A I was expecting one of the 4 objectives to include a tie between beaver activity and flooding patterns. This seems like it would be an important link to understanding the spring flooding patterns. It would be easy to tie into Obj. 3.

8.2.A Obj. 3. The fire history on Kanuti lends itself well to looking at moose forage availability and quality in burned areas of different ages; however, is there much information available on the fire behavior associated with the older burns? The intensity of fires has a tremendous influence on regeneration patterns and it would be good to try and quantify this information related to the browse studies. This would be possible to do at sites established in new burns and in some of the burns over the last decade, but I don't know of good techniques for this information from older fires (that doesn't mean that they don't exist - I just haven't found anything yet).

8.2.B Obj. 2. This should also be listed under the Fire Ecology section.

Consider including an objective to evaluate lichen levels similar to moose forage studies, and look for the effects of fire on lichens in recent burns.

The preliminary results from the JFSP study looking at lichen/fire/caribou suggest that caribou may begin to forage on lichens in areas that burned 60-80 years ago. It might be interesting to visit the 1950-1960 burns and evaluate the lichen composition abundance.

8.5 Obj 3 & 4. It would be good if the refuge could develop habitat models for raptors and Species of Concern in association with the inventory/distribution data.

8.5.B. Obj. 7 What about a tie to the beaver surveys?

Is there any interest in spring burns for waterfowl forage? There is an objective in the fire management plan that discusses using prescribed fire for waterfowl feeding and nesting habitat enhancement.

8.9.A Again, it seems like there should be a tie to the spring flooding patterns stated in this section. What about nutrient exchange following large-scale flooding events?

8.10.A Obj. 1. How many habitat types are represented by the eight transects? Are they enough to provide insight into long-term changes for a good portion of the refuge's habitat types?

Obj.3. Without more detail on protocols this is a little tricky. Somehow this will need to be closely tied to vegetation monitoring over time. There should also be some initial assessment of the fire severity through the area that will be monitored. In other words, how much of the area is in each of the burn categories (heavily, moderately, lightly burn or not burned). Unburned areas within/near your monitoring sites could impact the validity of your surveys.

Obj. 4. How do you intend to select your sites? Will they all be forested sites where you use tree cores? Will the sites expand beyond the refuge? Although I am supportive of a comprehensive understanding of fire history on the refuge, it may be more practical to focus the inventories to areas of the refuge with important ungulate foraging areas initially and use the cost savings to get a better understanding of fire effects from the more recent burns.

The fire/lichen/caribou objectives should be relisted or referenced again in this section.

Consider including an objective that would obtain information on the burn mosaics created by new fires on the refuge. Work with the FMO. Perhaps obtaining low-level aerial photos to determine the patchiness of the burn would be an option. Improving the refuge=s understanding of a fire=s behavior would help in understanding the long-term effects.

I didn=t realize that the fuels map has been completed for the refuge. I have seen the earth cover classification but not the fuels map. The fuels map can be used to generate some fire behavior models that would provide insight into how fires might burn in areas of interest (for example along the Dalton Highway) or near important wildlife habitat areas.

Figure 9 Include links between the waterfowl/waterbird/shorebirds and beaver.