ENVIRONMENTAL ASSESSMENT

Integrated Pest Management of Invasive Plants on Kodiak National Wildlife Refuge and Vicinity

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Prepared by

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1.0 Introduction

This Environmental Assessment (EA) addresses management of invasive plant species by Kodiak National Wildlife Refuge (NWR). An invasive species is an "*alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" (*Presidential Executive Order 13112). Invasive species can include a diversity of organisms including microbes, plants, and vertebrate and invertebrate animals. Our conservation concern with invasive plants regards their high potential to successfully establish, propagate, spread, displace native plants, disrupt ecosystem function, and degrade fish and wildlife habitat on Kodiak NWR and Alaska Maritime NWR lands in the Kodiak Archipelago. Allowing these impacts without management action to eliminate or contain such species is contrary to purposes for which these Refuges were established and is inconsistent with Service policy.

To avoid an adverse outcome, we need to implement a comprehensive management strategy to prevent, control and, where feasible, eliminate invasive plants on lands of Kodiak NWR and Alaska Maritime NWR lands in the Kodiak Archipelago.

Here we present three alternative approaches for future management. The first, the no action alternative, would discontinue Refuge and Service-sponsored management of invasive plants. The second alternative would adopt an Integrated Pest Management (IPM) approach that does not allow the use of herbicides. The third alternative would adopt an IPM approach and allow judicious use of herbicides in the appropriate situations. IPM is a systematic planning, evaluation, and decision-making process used to guide and direct management of pests such as invasive plant species (USFWS 2004). Specifically, the IPM approach requires evaluation of pest biology, infestation characteristics, environmental factors, and reported effectiveness and environmental impact of various methods of pest management including cultural (e.g., sanitation practices), biological (e.g., insect plant predators), manual (e.g., hand-pulling), mechanical (e.g., mowing), and chemical (e.g., herbicides) which, alone or combined, will minimize potential environmental impacts while also accomplishing the management objective. The outcome of the IPM evaluation process is a decision on the method, or combination of methods, which would be applied to manage these pest species infestations.

1.1 Purpose and Need for Action

The purposes of this EA are to: (1) present and evaluate three alternative approaches for invasive plant management; (2) propose selection of the alternative that best meets Service policy, Refuge purposes, and program objectives while minimizing potential environmental impacts; (3) provide an opportunity for public input on planning options; and (4) determine whether the scope and magnitude of impacts expected from implementation of the preferred alternative warrant preparation of an environmental impact statement (EIS). If significant impacts are expected, an EIS would be prepared. If not, the Refuge would implement the preferred alternative. In either case, the Service would disclose its final decision and supporting rationale in a separate decision document.

Kodiak NWR has written this EA both to respond to a 2008 lawsuit and because the threat of invasive species to Refuge lands is greater than original monitoring data indicated. In 2008 a non-profit organization sued the Alaska Region of the Fish and Wildlife Service regarding, primarily, Kodiak NWR's use of herbicide to eliminate invasive species and restore native plants. In 2009 the U.S District Court in Anchorage, Alaska, dismissed the suit following the Service's declaration of suspension of herbicide use on Alaska NWRs pending completion of National Environmental Policy Act requirements (NEPA). In response, Kodiak NWR discontinued use of herbicides and initiated this EA to comply with NEPA requirements including provision of public comment opportunity. Nevertheless, monitoring efforts since 2004 have shown that invasive species on Kodiak NWR and adjacent lands are a greater threat than documented in an earlier analysis based on 2003 data (USFWS 2003, USFWS 2008a). The more recent monitoring data have prompted the comprehensive analysis presented in this EA.

1.2 Background

The Refuge initiated management of invasive plants when an infestation of orange hawkweed (*Hieracium aurantiacum*) was discovered in July 2002 at Camp Island, located in Karluk Lake, southwestern Kodiak Island. Initial observations of this infestation indicated that cover and distribution of hawkweed was increasing and displacing native meadow plants. To date, the Refuge's management program has consisted of the following primary elements:

- Public outreach, in conjunction with the Kodiak Soil and Water Conservation District (District: KSWCD), to increase public awareness of invasive plant threats and to prevent establishment of new invasive plant infestations on the Refuges, and in the Kodiak Archipelago;
- Field surveys, in conjunction with the District, to document the type, location, and extent of infestations and environmental characteristics of infestation sites;
- Preparation of Integrated Pest Management (IPM) Plans for orange hawkweed, oxeye daisy *(Leucanthemum vulgare*), and Canada thistle (*Cirsium arvense*) (USFWS 2003, 2007a, 2007b). These plans were reviewed and approved by the Service's Alaska Regional Office;
- Completion of training, certification, and annual recertification of selected refuge personnel as pesticide applicators in accordance with 18 AAC 90.300.
- Evaluation and approval by the Service's Alaska Regional Office of Pesticide Use Proposals (PUPs), as required by Fish and Wildlife Service policy. These PUPs were reviewed and approved by the Alaska Regional Office, and the Washington D.C. Office (for the initial orange hawkweed PUP);
- Description of the invasive plant threat and establishment of a goal for management of native plants and an objective for survey, control, and

eradication of invasive plants in the Refuge's Revised Comprehensive Conservation Plan (RCCP) (USFWS 2008a);
- Secure federal funding dedicated to invasive species management, establish cooperative partnerships, and implement tactical aspects of plans including education; outreach; surveys; management of identified invasive plant infestations; follow-up monitoring of plant and habitat responses to management; and providing results to Service management and the public.

The approved IPM plans specified a combination of prevention, manual, mechanical, and chemical methods as needed to manage documented infestations of orange hawkweed, oxeye daisy, and Canada thistle on lands administered by the Refuge. Specifically, we annually surveyed and marked infestations; partly removed standing vegetation by hand or mower to facilitate subsequent herbicide treatment; applied one of two selective herbicides to invasive plants via direct foliar application to individual plants with backpack sprayers; and manually removed flowers of invasive plants during summer to reduce seed production as a preventative measure. Results from post-treatment plant community monitoring consistently indicated rapid restoration of native plants following reduction in the density of invasive plants. After herbicide use was prohibited in February 2009, we continued to implement IPM plan provisions, excluding herbicide use.

1.3 Legal Authorities

National Wildlife Refuges are required by law, policy, and purposes to protect and conserve fishes, wildlife, and plants while also ensuring that biological integrity, diversity, and environmental health are maintained. The following section summarizes the legal framework for management of invasive plants on Refuge lands in the Kodiak Archipelago.

Kodiak NWR and Alaska Maritime NWR are part of the National Wildlife Refuge System (NWRS). The legally mandated mission of the NWRS is "…to administer a national network of lands and waters for the conservation, management and where 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" (NWRS Administration Act of 1966, as amended [16 USC 668dd-668ee]). A relevant provision of the NWRS Improvement Act of 1997 mandates maintenance of *"…biological integrity, diversity, and environmental health of the System*…" (P.L. 105-97, Section (4)(B). This requirement was subsequently adopted as U.S. Fish and Wildlife Service (USFWS) policy in 601 FW 3 in 2001, where "FW" denotes "U.S. Fish and Wildlife Service Manual". Service policies pertaining to pest control include FWS 30 AM 12 (Pest Management Policy and Responsibilities), where "AM" denotes "U.S. Fish and Wildlife Service Administrative Manual", and 7 RM 14 (Pest Control), where "RM" denotes "U.S. Fish and Wildlife Service Refuge Manual".

In accordance with policy 7 RM 14, wildlife and plant pests on units of the NWRS can be controlled to assure balanced wildlife and fish populations in support of refuge-specific wildlife and habitat management objectives. Pest control on federal NWR lands and waters also is authorized under the following legal mandates:

- Administration Act of 1966, as amended (16 USC 668dd-668ee);
- Plant Protection Act of 2000 (7 USC 7701 *et seq*.);
- Noxious Weed Control and Eradication Act of 2004 (7 USC 7781-7786, Subtitle E);
- Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (7 USC 136-136y);
- National Invasive Species Act of 1996 (16 USC 4701);
- Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 USC 4701);
- Food Quality Protection Act of 1996 (7 USC 136);
- Executive Order 13148, Section 601(a);
- Executive Order 13112; and
- Animal Damage Control Act of 1931 (7 USC 426-426c, 46 Stat. 1468).

Pests control also is authorized by the U.S. Department of the Interior's Integrated Pest Management policy (517 DM 1), whereas "DM" denotes "U.S. Department of the Interior Manual". Under this Departmental policy, pests are defined as "…living organisms that may interfere with the site-specific purposes, operations, or management objectives or that jeopardize human health or safety." Similarly, 7 RM 14 defines pests as: "Any terrestrial or aquatic plant or animal which interferes, or threatens to interfere, at an unacceptable level, with the attainment of refuge objectives or which poses a threat to human health. The DM defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Throughout the remainder of this EA the terms pest and invasive species are used interchangeably.

Control of pests on Kodiak NWR and Alaska Maritime NWR would facilitate conservation and protection of fish, wildlife, and plant resources as well as maintenance of biological integrity, diversity, and environmental health. As described in 7 RM 14, animal or plant species which are considered pests may be managed if the following criteria are met:

- Threat to human health and well being or private property, the acceptable level of damage by the pest has been exceeded, or State or local government has designated the pest as noxious;
- Detrimental to resource objectives as specified in a refuge resource management plan (e.g., comprehensive conservation plan, habitat management plan), if available; and
- Control would not conflict with attainment of resource objectives or the purposes for which the refuge was established.

Service policy 620 FW 1 (Habitat Management Plans) provides additional management guidance regarding invasive species found on refuges:

- “We are prohibited by Executive Order, law, and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere.”
- “Manage invasive species to improve or stabilize biotic communities to minimize unacceptable change to ecosystem structure and function and prevent new and expanded infestations of invasive species. Conduct refuge habitat management activities to prevent, control, or eradicate invasive species...”

The Section 303(5)(B) of Alaska National Interest Lands Conservation Act of 1980 (ANILCA) revised and expanded the purposes of Kodiak NWR, and established purposes for Alaska Maritime NWR [Section 303(1)(B)]. Mutually shared purposes for these two refuges that are relevant to this EA include:

- “…conserve fish and wildlife populations (and) habitats in their natural diversity…;
- …provide… the opportunity for continued subsistence uses by local residents…”; and
- …ensure, to the maximum extent practicable…water quality and necessary water quantity within the refuge.”

Consistent with amendments to the NWRS Administration Act of 1966, Service policy 601 FW 3 (which mandates that the Service maintain the biological integrity, diversity, and environmental health), and specific Refuge purposes established under ANILCA, we are mandated to protect and conserve native fish, wildlife, and plant species. Pest management activities that will enhance our ability to meet these management goals include: (1) prevent introduction of non-native plants and minimize the impact of existing infestations via control or removal, and (2) adopt control or removal practices that prevent or minimize collateral adverse effects to the environment, subsistence use opportunity, water quality, and human health. Corresponding plant management goals were prescribed in the Kodiak NWR’s Revised Comprehensive Conservation Plan (RCCP) (USFWS 2008). Specifically, the RCCP goal states: “…maintain and restore native plant populations, communities, and habitats”. The priority objective under that goal states: “Develop and conduct reconnaissance surveys of invasive plants…and where invasive plants are detected, initiate collaborative control and eradication actions.”

As directed by the Service’s Ecosystem Approach policy (052 FW 1) and its National Strategy for Management of Invasive Species (USFWS 2004), Kodiak NWR will work in partnership with public agencies, private organizations, landowners, and citizens to control and eliminate invasive plant species to perpetuate a dynamic, healthy Kodiak Archipelago ecosystem. Attainment of this goal requires cooperative education, prevention, and control actions inside and outside the Refuge boundaries. Without action, invasive plants will spread to suitable habitat and compromise ecosystem integrity regardless of ownership or jurisdiction. Therefore, though this EA primarily concerns management of invasive plants in Kodiak NWR and Alaska Maritime NWR, it also addresses facilitating effective management beyond refuge boundaries.

Kodiak NWR administers Conservation Easement Agreements on private lands owned by three Native Corporations on 104,691 acres of land within the legislative boundary of Kodiak NWR on Kodiak Island (USFWS 2008). Habitat conservation is the principal purpose of these Agreements. The easements provide the Service with certain authorities including access and the responsibility for managing habitat, including invasive plants, in coordination with the Native Corporations.

As described above, the Service will utilize an IPM approach when managing invasive plants, including the use of herbicides when necessary. We approach the use of herbicides, one of the potential tools to manage invasive plants, with caution. In general, our approach includes: a requirement to carefully consider all potential control methodologies and apply an IPM approach to evaluate the efficacy and environmental impact of different management methods. Before herbicide use can be initiated, Service policy requires preparation and approval of a Pesticide Use Proposal (PUP). These PUPs describe the pest-, site-, and chemical-specific proposal for review and authorization by the appropriate agency specialist (e.g., Environmental Contaminant Specialists in the Alaska Regional Office, or in some cases at the national headquarters office) and the Refuge Manager. Refer to Appendix A for more information on the PUP process.

IPM Plans are another approach the Kodiak NWR has used to fully evaluate and describe available control options for specific locations and/or plant species. These plans require authorization of the Refuge Manager and Refuge Supervisor before they can be implemented. Following these authorizations, plant control projects are implemented.

When herbicides are used, applicators must follow all requirements of the pesticide label, including prescribed application rates and techniques, public re-entry requirements, pesticide mixing and storage, and applicator protection standards such as use of personal protective clothing. While not always required by the pesticide label, Kodiak NWR requires supervision of all chemical applications by a pesticide applicator that has been certified by the State of Alaska.

1.4 Issues

1.4.1 Issues Selected for Detailed Analysis

When preparing this Environmental Assessment, the Refuge solicited public input on methods it may use to manage invasive plants. Refer to Appendix B for a copy of the solicitation letter. We also considered allegations made in the aforementioned lawsuit. Responses we received from the public expressed concerns about the potential detrimental effects of herbicide in general and the two herbicides proposed for future use. These concerns were considered in the development of three alternative actions. In Chapter 4, we identify, describe, and compare the ecological and human health impacts of the alternatives. Primary concerns we received in scoping comments are described below.

1.4.1.2 Comments on Ecological Effects

Concern was expressed about the potential of herbicides to:

- Migrate beyond the site of application;
- Persist before degrading into non-toxic compounds;
- Contaminate ground and surface waters;
- Affect non-target vegetation growth in treated sites;
- Affect soils, soil chemistry, soil fauna, and insects;
- Affect aquatic life and fishes particularly salmonids;
- Affect wildlife including those that might feed on vegetation in sites where herbicide has been applied
- Exhibit effects different in Alaskan environments, including Kodiak Island, compared to areas in the contiguous U.S. where effects were evaluated per EPA registration requirements.

1.4.1.3 Comments on Human Health

Concern was expressed about the potential of herbicide to adversely affect:

- Humans who consume fish potentially contaminated with herbicide;
- Humans who harvest plants and animals from areas in and adjacent to sites subject to herbicide application;
- Subsistence, recreational, and commercial uses;
- Children and chemically-sensitive individuals; and
- Human health.

1.4.1.4 Comments on Adjuvants

Some commercial herbicide formulations contain ingredients in addition to the active ingredient primarily responsible for biocide action. These other ingredients, called adjuvants, are added to enhance the performance of the herbicide or efficiency of the herbicide application, such as colorants or surfactants (Tu et al. 2001). In some cases, adjuvants are added to the active ingredient in the technical formulations sold by the manufacturer, and in other cases adjuvants may be produced and marketed independently and combined with water and herbicide in a mixing tank by the applicator in a quantity prescribed by the herbicide label. Several comments pertained specifically to the effects of adjuvants on ecological and human health, including concerns that the chemical fate, transport, and human and environmental toxicology of these compounds may be poorly described or unknown.

2.0 Alternatives

In this section, we describe a reasonable range of alternatives for management of invasive plants by Kodiak NWR. Three alternatives are presented. Implementation of two of the three alternatives would entail application of an IPM approach. However, only one alternative would allow for herbicide use. Common elements shared by the two IPM alternatives are highlighted separately. Alternatives we considered but rejected are described at the end of the section. Refer to Table 3.3 at the end of this chapter for a comparison of summarized characteristics of the two IPM alternatives.

2.1 Alternative 1: Discontinue Management of Invasive Plants *(no action alternative)*

Alternative 1 would discontinue management of invasive plant species. The Refuge would not direct any time, personnel, and funding resources to support management actions. Specifically, we would not:

- Engage in public outreach related to invasive plant species;
- Survey to determine the identity, location, and extent of invasive species infestations within and surrounding Kodiak NWR and Alaska Maritime NWR;
- Engage in scientific monitoring and research related to invasive species;
- Undertake any direct action to control or eradicate invasive species;
- Sponsor or otherwise indirectly support the use of Service funds, equipment, or personnel by any non-Service organization for purposes of invasive species outreach, survey, monitoring, and control; and
- Maintain involvement in the Kodiak Archipelago Cooperative Weed Management Area.

2.2 Elements Common to Alternative 2 and Alternative 3

Effectiveness of invasive plant management is determined by two primary factors: public awareness of invasive species and effective monitoring strategies. Public awareness is required to prevent continued spread of existing invasive species, as well as establishment of additional invasive species to the Kodiak Archipelago. Knowledge of invasive species status enables us to coordinate private-public sector actions.

Under both alternatives, Kodiak NWR would continue its campaign, in coordination with its conservation partners, to increase public awareness and to monitor the status and trends of invasive plants and the means by which they spread. Below we describe primary elements of outreach and monitoring.

2.2.1 Outreach

Outreach would have three primary purposes: to increase public awareness of invasive plants, to prevent deliberate or inadvertent establishment of invasive plants, and to facilitate management of documented highly invasive plants (Table 2.1). In coordination with the District and other partners, Kodiak NWR would continue to develop and distribute information on the identification, ecology, and management of invasive plants. Previous practices would continue including:

- Public presentations (e.g., annual county fair, slideshows);
- Meeting with public and government officials to provide information about invasive plants, and to discuss their management; and
- Management of invasive plant species with the highest potential to adversely impact native plant communities, refuge purposes, ecosystem services, and dependent human uses (Table 2.1).

2.2.2 Inventory and Monitoring

The purpose of inventory would be to determine the occurrence, identity, and distribution of invasive plant infestations. The purposes of monitoring would be: (1) document changes in invasive plant population size and locations and (2) monitor ecological response to management actions of species considered highly invasive (Table 2.1).

Table 2.1. Known invasive species of plants with the greatest potential to adversely impact native plant communities and ecosystem services in the Kodiak Archipelago. Species in bold have been documented within the legislative boundary of Kodiak NWR, properties managed by the Refuge in Kodiak, or federal lands of Alaska Maritime NWR in the Kodiak Archipelago, as of May 2010.

Species	**Growth Form**	**Invasiveness Rank[1]**
Bohemian knotweed (*Polygonum X bohemicum*)	Shrub	87
Giant knotweed (*Polygonum sachalinensis*)	Shrub	87
Reed canarygrass (*Phalaris arundinacea*)	Grass	83
Orange hawkweed (*Hieracium aurantiacum*)[2]	Forb	79
Canada thistle (*Cirsium arvense*)[2]	Forb	76
European bird cherry (*Prunus padus*)	Tree	74
Common toadflax (*Linaria vulgaris*)	Forb	69
Siberian pea shrub (*Caragana arborescens*)	Shrub	64
Yellow alfalfa (*Medicago sativa ssp. falcata*)	Forb	64
Oxeye daisy (*Leucanthemum vulgare*)[2]	Forb	61
Bull thistle (Circium vulgare)	Forb	61
European mountain ash (*Sorbus aucuparia*)[2]	Tree	59
Common tansy (*Tanacetum vulgare*)[2]	Forb	57
Creeping buttercup (*Ranunculus repens*)	Forb	54
Splitlip hempnettle (*Galeopsis bifida*)	Forb	40

[1]Ranking derived by Carlson et al. (2008). Evaluation included 113 nonnative species ranked on a scale of 0-100 in probable invasiveness.
[2]Known to occur on federal lands or on private lands under Conservation Easements.

With few exceptions we adopted the results of Carlson et al.'s (2008) ranking of relative level of invasiveness of non-native plants found in Alaska (e.g., Table 2.1). Invasive species of greatest concern to the Refuge are those which ranked 60 and higher in accordance with Carlson et al (2008). Combined field observations made by Refuge and District personnel generally corroborated Carlson et al.'s (2008) rankings except for four species: European mountain ash, common tansy, creeping buttercup, and splitlip hempnettle. Though these species were ranked as weakly to moderately invasive by Carlson et al. (2008), we consider them highly invasive in the Kodiak Archipelago. Our conclusion is based on field observations which indicated displacement of native perennial forbs on undisturbed and minimally disturbed sites (W. Pyle, Kodiak NWR, pers. obs.; B. Brown, District, pers. comm.).

In cooperation with the District we would continue to inventory for invasive plants. The scope of the Refuge's inventory effort would focus on federal and private land within the legislative boundaries of Kodiak NWR (Figure 2.1), properties managed by the Refuge in Kodiak (Figure 2.2), and federal lands of Alaska Maritime NWR in the Kodiak Archipelago (Figure 2.3). Collectively these areas include about 1.6 million acres of federal land and about 147,000 acres of private land (USFWS 2008a). On about 104,000 acres of private land, Kodiak NWR has authority to manage habitat, including invasive species, by virtue of Conservation Easement Agreements with Native Corporations. The District would continue to address inventory needs on remaining state and private lands in the Kodiak Archipelago with emphasis on the road connected area in Kodiak and the six outlying village communities.

Consistent with previous efforts, our inventory work would primarily target sites of existing and historic human settlement and use, most of which are distributed along the coast. We would request permission of the landowner to access and inventory private lands within the legislative boundary of Kodiak NWR. Data collected during field visits would include occurrence, identity, and geographic extent of invasive plants, accompanied by photos. Data acquired from inventories would be catalogued in databases managed by the Refuge and District. The District would annually submit this information to the Alaska Exotic Plants Information Clearing House http://akweeds.uaa.alaska.edu/. The Refuge would develop and deliver reports of inventory results to USFWS management and the public.

Remote undeveloped areas would be inventoried opportunistically in conjunction with other Refuge-operated biological surveys, and specific inventory efforts would be initiated when we received a report indicating that an invasive plant had been observed. In such a case, we would travel to the site of the observation and survey it and the surrounding area. We would expect that our inventory efforts would decrease and efforts directed toward monitoring would increase through time as areas frequented by public and sites of past human settlement are assessed.

Consistent with the initial inventory approach outlined above, the scope of longer-term monitoring would focus within the legislative boundary of Kodiak NWR and on federal land of Alaska Maritime NWR in the Kodiak Archipelago. Monitoring would focus primarily on sites where inventory results documented invasive plant infestations. Data collected during monitoring would include occurrence, identity, distribution, photo documentation at specific reference points, and assessment of the efficacy of management actions taken to control invasive plant species. We may collect additional data to more fully quantify the response of invasive and native species where the Refuge led, or cooperated in, management of an infestation following implementation of a particular control action, or set of control practices. Following conclusion of fieldwork, monitoring data would be organized, analyzed, and interpreted to assess the extent to which treatment and habitat management objectives were accomplished. We would generate and deliver results in reports to management, and subsequently post these on the Refuge's website. We would periodically revisit human settlement and use sites included in the initial inventory, which at the time lacked invasive plants of management concern, in order to identify new infestations early in the invasion cycle when they are most amenable to control efforts.

2.2.3 Ecological Threshold for Management of Invasive Plants

Refuges are managed to protect and conserve native plant communities and the ecosystem services they provide as directed by Service policy 601 FW 3. Consistent with this directive, and others stated in the Refuge's RCCP (USFWS 2008a), control and/or eradication action (including planning for the actions) would be initiated when one or more plants of any highly invasive species is detected on federal land and lands under Conservation Easement Agreements where the Refuge is authorized to manage habitat.

2.2.4 Adaptive Management

Based upon 522 DM 1 (Adaptive Management Implementation policy), refuges shall utilize adaptive management (AM) for conserving, protecting, and, where appropriate, restoring lands and resources. Within 43 CFR 46.30, AM is defined as a system of management practices based upon clearly identified outcomes, where monitoring evaluates whether management actions are achieving desired results (objectives). The recently published *DOI Adaptive Management Technical Guide* also defines AM as a decision process that "promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood". AM accounts for the fact that complete knowledge about fish, wildlife, plants, habitats, and the ecological processes supporting them may be lacking. The role of natural variability contributing to ecological resilience also is recognized as an important principle for AM. It is not a "trial and error" process, but rather AM emphasizes learning while doing based upon available scientific information and best professional judgment considering site-specific biotic and abiotic factors on refuge lands.

Figure 2.1. Kodiak NWR and vicinity, Kodiak Archipelago, Alaska.

Figure 2.2. Refuge-managed properties in the vicinity of Kodiak, Alaska.

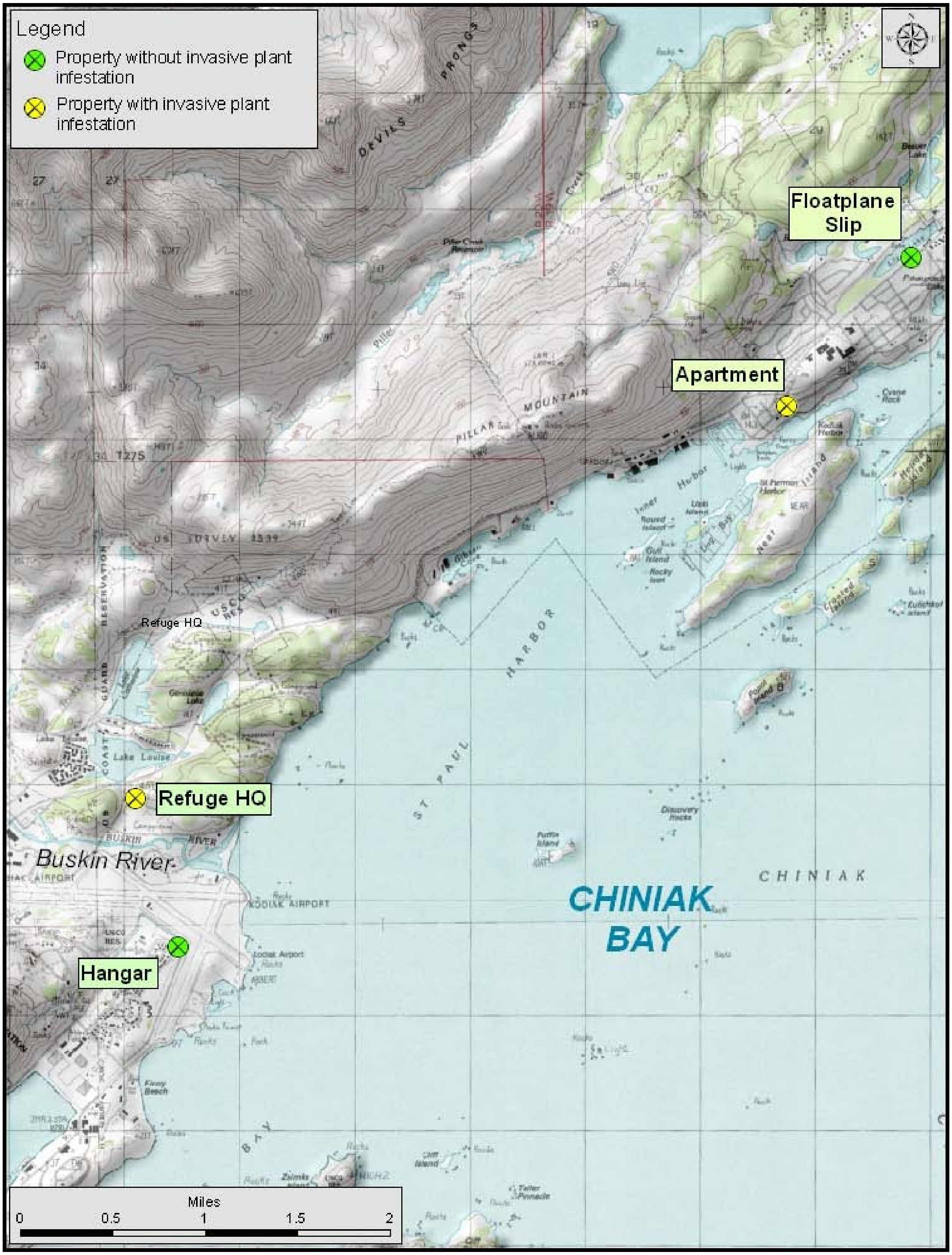


Figure 2.3. Alaska Maritime NWR in the Kodiak Archipelago, Alaska.

2.3 Alternative 2: An IPM Approach without Herbicide Use

Infestations of 15 highly invasive plant species (Table 2.1), and any others that present a similar level of risk would be actively managed with an incomplete, or partial, IPM approach which would exclude the use of herbicides. Although initial management activities would focus on the 10 species of highly invasive plants currently known to occur within refuge boundaries, our activities could include any other highly invasive species documented in future surveys. The following criteria would be applied to determine priority and scope of infestation management. Our first priority would be to address infestations on Refuge lands, as well as private lands included in Conservation Easement Agreements where the Refuge has management responsibilities. The Refuge is only one part of the larger Kodiak Archipelago landscape, and effective weed management would require coordination and cooperation among many different entities. For example, the Refuge is seriously concerned about infestations on other (non-easement) private lands in the legislative boundary of Kodiak NWR, as these could serve as source areas for the spread of invasive plants onto Refuge lands. Finally there are some known infestations on private, municipal, and state land outside the NWR boundary that could serve as source areas, due to their proximity to the Refuge or presence within the same watersheds as Refuge lands.

In cases involving private or state land, we would facilitate cooperation between the landowners, the District, and the Refuge. The purposes of this cooperation would be: (1) to advocate for the use of an IPM approach to manage documented infestations of highly invasive plant species, and (2) to provide technical assistance to the landowner and District, as requested, including advice on management options; demonstration of management methods; and participation in management actions at the request of the landowner.

In some cases, we anticipate that a landowner may request either financial or direct management assistance from the District and cooperators such as the Service. Other sources of Service funding which could be used to help partners address weed management issues could include (but are not limited to) the Service's Coastal, Partners for Fish and Wildlife, and Tribal Wildlife Grants programs. Work supported by these other Service programs to control highly invasive plants would be included within the scope of this EA, if they utilize the same IPM approach and techniques described in this document. Projects which fall outside the scope of this EA would need to ensure that the appropriate level of NEPA had been conducted for that work.

The Refuge may also be able to provide certain types of technical advice and/or direct assistance. Should a landowner request the District to manage an infestation and the District requests support of the Refuge, the scope of Refuge cooperation would be limited, under this alternative, to use of IPM methods that did not involve application of herbicides. However, if this partial IPM approach is adopted, while we may encourage a similar approach by the cooperators, its limitations on the use of herbicides could not be imposed on them. Similarly, in some cases, a landowner may decline to manage an infestation, regardless of any offer of assistance by District and its cooperators. Such a decision would be the landowner's right.

Consistent with policy (517 DM 1 and 7 RM 14) an IPM approach except in its exclusion of a specific management option would be applied to facilitate pest management decisions. This policy also encourages, but does not require, completion of IPM Plans to document the pest management evaluation and decision process. Though not required, all the major pest management decisions rendered by Kodiak NWR during 2003-2008 applied an IPM approach including completion of species-specific IPM Plans by Refuge personnel. Species addressed in these plans included orange hawkweed (USFWS 2003), oxeye daisy (USFWS 2007a), and Canada thistle (USFWS 2007b). Under this alternative we would apply a more limited partial IPM approach but still document the pest management evaluation and decision process in an IPM plan for one or more species and infestation sites. Our existing IPM plans would be reviewed, evaluated, and modified to exclude chemical methods of management while maximizing use of non-chemical methods of management to attempt to attain the goal of containment or where possible the elimination of orange hawkweed, oxeye daisy, and Canada thistle. Existing IPM plans would be amended as appropriate when new infestations were identified, and where field observations indicated that, because of differences in site and/or infestation characteristics, a different non-chemical method or combination of non-chemical methods may be required to best attempt to attain management goals.

IPM methods described below summarize the primary non-chemical methods that would be applied to manage highly invasive species. The use of these various techniques will depend upon the biology of the target plants, physical characteristics of the site, the remoteness of the site, and the habitat management goals established by the Refuge.

Cultural Control and Prevention. Cultural methods typically involve manipulation of the habitat to make it less suitable to the pest and preventative measures to reduce the spread of a species and/or prevention.

Prevention of new infestations would be a major area of emphasis for the Refuge, as this is the most cost effective way to minimize future introductions, a key goal of any long-term management strategy. Outreach would be conducted and sanitation practices would be applied to prevent inadvertent off-site transportation of invasive plants. Refuge staff, Refuge cooperators, and commercial operators with special use permits (e.g., commercial set-net fishers, air taxi operators, sport fish, hunting, and wildlife viewing guides) would be required to inspect equipment, personnel, and clients for invasive plant parts or seed and to clean, and dispose of these as appropriate. Following conclusion of Refuge invasive plant management actions, we would inspect equipment used in the operations and steam clean it if inspection revealed evidence of invasive plant parts or seeds.

Commercial businesses must annually request, and receive Refuge approval for commercial activities on refuge lands. In 2009, we issued a total of 95 permits to businesses engaged in commercial activity on Kodiak NWR. Permit applicants are required to submit an operations plan for review and approval by the Refuge. Once the permit is approved, a permittee must adhere to their operation plan and permit stipulations promulgated by the Service. To prevent introduction of invasive plants to the Refuge via permitted commercial activities, we would modify permit stipulations to prohibit invasive plants and require inspection of equipment, gear, or clients for contamination before a commercial activity can be conducted on the Refuge. For instance, a stipulation was added to special use permits of shore-based salmon set-net fishers in 2010 prohibiting introduction of non-native plants, except garden vegetables, to set-net facility sites based on Kodiak NWR land.

Other examples of cultural control practices that may be appropriate for certain situations on Kodiak include mulching and burning. While natural re-vegetation effectively re-established native ground cover in treated areas on the Refuge, active re-vegetation may be another cultural practice that might be necessary under certain circumstances.

Biological control. These methods typically involve the release of host-specific non-native insects that consume a portion of the host-plant, reduce its vigor, and in some instances inhibit or prevent reproduction. There are no commercially available biological control agents currently available for the highly invasive species listed in Table 2.1 except for Canada thistle. If these products become commercially available, have been carefully tested (including assessment of risk that a non-native control agent could itself become invasive), and are certified for use in Alaska, we would evaluate and potentially apply them following an IPM evaluation process. In the case of Canada thistle, several products are currently available. However, the Refuge does not presently propose use of these control agents because they usually are most effective when introduced into large infestations (a relatively large target plant population is needed to sustain populations of the control agent) and these insects do not kill thistle plants.

Manual control. Manual control methods involve removing invasive plants by hand or through the use of hand tools. We anticipate that this would be the primary method for management of most existing infestations. Location of infestation sites of highly invasive species would be recorded with a GPS. Standing dead vegetation would be manually cleared to expose all spring growth of perennial invasive herbs (i.e., forbs and grasses) at each site. The perimeter of each infestation site would be marked with biodegradable flagging. Field workers would use various digging and cutting hand-tools, such as shovels, spades, trowels, saws, and dandelion diggers to remove roots of invasive perennial herbs and, in some cases, shrubs (e.g., knotweed). Native plants and topsoil would be removed as needed to facilitate access to roots of invasive plants. Removed invasive plants would be double bagged, incinerated on site, or transported to City of Kodiak for incineration or burial. Following treatment, topsoil and remaining native plants would be replaced to the extent feasible. Follow-up visits would be made to infestation sites during summer to gauge success, remove and bag flowers of surviving invasive plants, incinerated on site, or transported to City of Kodiak for incineration or burial. Removed flowers would be transported back to Kodiak and incinerated. Because this activity itself involves a risk of spreading the invasive plant (e.g., seeds or plant parts stock to boots, laces, gloves, etc.), prevention could be addressed in an IPM plan to identify risk reduction requirements.

<u>Mechanical and other physical controls.</u> Mowing is one type of mechanical control that could be used to minimize flowering and seed spread of invasive perennial herbs for sites where mowing is practicable. Repeated mowing can also stress some plants, reducing their vigor. Cutting with a chainsaw could remove above-ground growth of large invasive shrubs and trees. However, mowing and cutting are generally considered ineffective for perennial invasive herbs that also propagate vegetatively from rhizomes or stolons, which includes all the herbaceous species listed in Table 2.1. Because this activity also involves a risk of spreading an invasive plant (e.g., seeds or plant parts stuck to a mower undercarriage or chainsaw blade or casing, etc.), prevention could be addressed in an IPM plan to identify risk reduction requirements.

Other physical methods also may be appropriate for certain plant species, in certain locations. For example, some shade intolerant species may be controlled through the use of barriers or tarps in certain (flat) locations.

2.4 Alternative 3: An IPM Approach with Herbicide Use *(preferred alternative)*

Documented infestations of highly invasive plant species would be actively managed with an IPM approach, using a suite of preventative, cultural, biological and/or physical methods as described in Alternative 2. Under this alternative targeted herbicide use would be allowed when necessary to achieve site management goals, and in compliance with all applicable Service policies and legal authorities.

The same criteria would be applied to determine priority and scope of infestation management as described in Alternative 2. Additionally, when the District is requested by a landowner to manage the infestation and the District requests support of the Refuge, the scope of Refuge cooperation could include application of any recommended IPM methods including use of herbicides.

We currently propose the use of two herbicides with the active ingredients aminopyralid and glyphosate. Either of these could be used following assessment of infestation site characteristics, target species life history characteristics, an IPM evaluation of potential control techniques, and agency review and authorization of site- and herbicide-specific PUPs. Aminopyralid would be used to manage infestations of highly invasive species of broadleaf forbs in upland environments. For example, it would be used to manage upland infestations of orange hawkweed at Camp Island, Canada thistle at Garden Island, and oxeye daisy at refuge headquarters in Kodiak. Glyphosate may be used to manage some of the same forb species where they occurred near water. However, glyphosate would be used primarily to treat highly invasive grasses, shrubs, and trees including species that occurred in either upland or wetland areas. In the field, two adjuvants, a non-ionic surfactant and a colorant would be added to the tank mix containing herbicide and water to improve herbicide efficacy and application efficiency.

In all cases where Refuge personnel conduct herbicide application, or where Service funds specifically support herbicide application (e.g., via the Coastal, Partners for Fish and Wildlife, or Tribal Wildlife Grant Programs), a chemical-specific Pesticide Use Proposal (PUP) would need to be prepared, thoroughly reviewed, and approved prior to herbicide use.

We would employ an action threshold when considering management of invasive plants with herbicides. We would manage invasive plants exclusively with non-herbicide methods where an infestation consisted of 10 or fewer invasive plants per infestation area. An infestation area is defined as one or more invasive plants or geographically separated groups (populations) of invasive plants collectively encompassed within a relatively small and geographically distinctive place. For example, an infestation area may consist of a single place with an isolated population of three orange hawkweed plants. However, an infestation area also may consist of 50 or more populations—each a single infestation—of hawkweed plants collectively distributed within a geographically distinct area, such as occurs on the 48-acre Camp Island, Karluk Lake. To further expand upon this example, we recognize four geographically distinct areas of hawkweed infestation in the Camp Island vicinity based on separation among areas by major water barriers.

Herbicide could be selectively applied where the number of invasive plants did not exceed 10 per infestation area and:

- manual and/or mechanical means were deemed infeasible; or
- manual and/or mechanical methods were attempted but failed to eliminate invasive plants; and
- Refuge objectives for the area could be met while minimizing environmental effects.

The scope of any future aminopyralid applications would be limited to terrestrial uplands and application of it would be prohibited within 10 feet of water bodies (USNPS 2008). While a specific glyphosate brand or product will not be identified within this EA (as different products and brand names are periodically added or removed from the market), only commercial formulations registered for use in both upland and aquatic environments could be used. Currently Aquamaster® is one example of a glyphosate-based herbicide that is registered in Alaska and which meets these performance criteria.

Only the least toxic of non-ionic surfactants (e.g., EPA acute toxicity rating of "practically non-toxic" with an acute LC50 > 100 mg/L) may be used to increase performance and efficacy of aminopyralid and glyphosate. Toxicity will be assessed using available technical reports, peer-reviewed journal articles, Material Safety Data Sheets, comparative literature reviews, and similar sources. Past chemical treatments on the Refuge have utilized the surfactant AGRI-DEX® which has much lower aquatic toxicity than most, if not all, comparable products (Monheit et al. 2004, Smith et al. 2004). Finally, annual herbicide use would be limited to potential maximum volumes of 2.5 gallons of a commercial formulation with aminopyralid (Milestone™VM) and 32.5 gallons of a commercial formulation with glyphosate (Aquamaster®).

Chemical treatment methods would be used in conjunction with selected manual and mechanical practices as appropriate. The primary method of herbicide application would be direct foliar application with a backpack sprayer. Selection of the specific application method would be based on evaluation of species life history characteristics and review of techniques that other IPM practitioners have found to be effective with a particular species. The direct foliar application method would involve a conventional backpack sprayer fitted with small (e.g., four-gallon) tank, manually-activated pressure pump, and single or multi-nozzle spray applicator. The cut-stem method would involve painting herbicide on to cut stems or stumps of highly invasive shrub or tree species. The injection method would involve use of a specially designed syringe to inject herbicide into the base of an invasive shrub stem.

Table 2.2. Proposed herbicides and their characteristics.

Active Ingredient (Formulated Product)	Target Species (as of May 2010)	Mode of Action	Method of Application
Aminopyralid (Milestone™VM)	Orange hawkweed, Canada thistle, oxeye daisy, creeping buttercup, yellow alfalfa, bull thistle, common tansy, splitlip hempnettle	Disturbs plant growth and is absorbed by green bark, leaves and roots, and moves throughout the plant. Accumulates in the meristem (growth region) of plant.	Ground-based spot spraying with a manually operated backpack sprayer. Best management practices include wind restrictions, use of coarse spray to reduce drift potential, spraying with a low wand height to reduce drift.
Glyphosate (Aquamaster®)	Reed canarygrass, bohemian knotweed, Siberian pea shrub, European mountain ash	Absorbed by leaves and rapidly assimilated into plant tissue. Prevents plant from producing an amino acid essential to growth and survival.	Ground-based spot spraying with a manually operated backpack sprayer, as above. Also wiping of herbicide on cut shrub or tree stems, or injection into shrub stems.

Before field deployment each year, herbicide application equipment would be tested for functional condition and calibrated to achieve the appropriate application rate. In backpack sprayers, for example, application rate is regulated primarily by species-specific volumes listed on the herbicide label, tank pressure level, walking speed, and spray droplet size. Calibration would occur via the standard method of filling a tank with one gallon of water, pumping the handle to maximum pressure (e.g., 15 psi), holding the applicator near the ground, moving it back and forth, spraying water, maintaining pump pressure until the water is expended, and computing the area sprayed. Refuge staff certified as pesticide applicators by the Alaska Department of Environmental Conservation would be responsible for training of staff and cooperators to be involved with herbicide applications, and certified applicators would supervise all herbicide applications. Training would include review of herbicide product label specifications for herbicide use, review of the Material Safety Data Sheet (MSDS) for the herbicide and adjuvant products, application objectives and conditions, best management practices to ensure on-target delivery of herbicides with minimal drift, safety requirements, and proper equipment use.

Infestation sites targeted for application of herbicide would be visited before the application to prepare them for herbicide treatment. A combination of preparation practices may be employed depending on the species targeted for control and the stage of plant growth. In the case of spring applications of aminopyralid, invasive plant infestations would be visited between mid-May and early-June, invasive plants would be exposed by manually clearing standing vegetation as needed, and perimeters of infestation sites would be delineated with biodegradable flagging. In the case of fall applications of aminopyralid timed to target invasive plants during the re-growth period, we would precede the herbicide application by manually removing (and bagging and destroying) the flowers followed by mowing of the site. Such preparation can prevent seed dissemination, increase the visibility of invasive plants to herbicide applicators, decrease the amount of herbicide applied, lower the risk of spray drift, and minimize the exposure of non-target plants to herbicide.

In accordance with Alaska Pesticide Control Regulations (18 AAC 90.630), areas considered “public” would be posted before herbicide application with a temporary closure notification. Re-entry periods specified on the label would serve as the minimum closure period. Closures could be extended at the discretion of the Refuge Manager. Information on this notification would include the application date, duration of closure, name of the commercial herbicide product, and EPA registration number. Once the project site was appropriately prepared and public notice was issued regarding the plan for herbicide application, we would commence the application phase of a project.

Personnel involved in the application including bear safety guards would be required to wear personal protective equipment (PPE) during herbicide application as stipulated in the herbicide product label, IPM Plan, and/or PUP proposal and approval conditions. Consistent with previous practice, the Refuge would meet and exceed label PPE requirements in the future. Materials and supplies needed for the application would be transported to a designated mixing site in upland near the application area. In the case of backpack spraying treatments, chemicals including the herbicide, a low toxicity surfactant, and a colorant would be carefully measured and sequentially mixed with water in the tank in accordance with the herbicide product label. Following mixing, personnel would mount the backpack sprayers, walk to the infestation site, and proceed with application. Following herbicide application, equipment would be thoroughly cleaned. In most cases, treatment success would be evaluated the following year before additional treatment occurred.

2.5 Alternatives Considered but Eliminated from Analysis

A party suggested that herbicide use should not be included as an alternative for management of invasive plants. We address this suggestion with provision of two Alternatives (1 and 2) that disallow use of herbicides for the management of invasive plants. Nevertheless, after consideration of all Alternatives, we have selected Alternative 3 because we do not believe an IPM approach disallowing herbicides will allow us to completely eradicate invasive plant species from infested areas on Refuge lands. Moreover, some infestations may be extremely difficult to eliminate or control without herbicide use, or in some cases, manual or mechanical control methods would cause greater impact than herbicide use. Furthermore, Service policy for Integrated Pest Management (562 FW 1) and its strategy for management of invasive species (USFWS 2004) require consideration of chemical and non-chemical approaches to pest management,

It was suggested that we should expand the scope of the EA to programmatically address invasive plant management at all National Wildlife Refuges in Alaska. This item was discussed by officials at Kodiak NWR and the Alaska Regional Office before we issued the scoping letter in July 2009. It was decided that, for the time being, each of the refuges would maintain responsibility for individually completing NEPA planning requirements associated with integrated pest management.

Table 2.3. Comparison of the action alternatives. (Alternative 1 is Discontinue Management of Invasive Plants)

Category	**Alternative 2: IPM without herbicide**	**Alternative 3: IPM with herbicide**
Geographic scope	Priorities include infestations on federal land of Kodiak NWR and Alaska Maritime NWR, including Refuge-managed properties in Kodiak, followed by infestations on private land in the legislative boundary of Kodiak NWR.	Same as Alt. 1
Invasive species	Includes 15 highly invasive species known to occur in Kodiak Archipelago. Ten of the 15 species presently occur on federal and private land within the legislative boundary of Kodiak NWR, federal land of Alaska Maritime NWR, or Refuge-managed properties in Kodiak.	Same as Alt. 1
Control methods	Exclusively manual and mechanical.	Manual, mechanical, and chemical. Chemical herbicide use generally limited to areas where density of highly invasive plants exceeds 10 plants per infestation area.
Herbicides	None.	Aminopyralid (e.g., Milestone™VM) and glyphosate (e.g., Aquamaster®). Maximum annual herbicide use limited to 2.5 gallons of Milestone™VM and 32.5 gallons of Aquamaster®.
Acres treated	Number of acres increase to an undefined upper limit determined by limits of personnel and funding. Small infestations successfully eliminated; some large infestations not eliminated due to deficient management capacity.	Number of acres initially increase as more areas are treated followed by gradual decline as infestations successfully eliminated or contained to a very small size (less than a tenth acre).
Effectiveness	Ninety percent of small infestations eradicated in five years. Large infestations: overall less than 50% of sites successfully contained or eliminated.	Ninety percent of small infestations eradicated in five years; 50% of large infestations eradicated in five years following initial treatment; and 100% of infestations eradicated in 10 years following initial treatment.
Human health	Hazards readily predicted, observed, and controlled. Cumulative impact negligible and temporary.	Hazards associated with manual and mechanical methods readily predicted and controlled. Hazards associated with chemical methods also understood and controlled via restriction of use to products of low toxicity and compliance with stipulated regulatory, agency, and product standards for safe use. Cumulative impact negligible and temporary.
Ecological effects	Negligible short-term impact associated with management of small infestations. Minor impact associated with management of large infestations due to substantial disturbance associated with removal of topsoil and non-target plants during and following removal of invasive plants including all root matter. Long-term cumulative impact increases from minor to moderate due to ineffectiveness of control at, and eventual expansion of, largest infestations and progressively increasing adverse impacts to plant community composition, fisheries and wildlife habitat, and ecosystem services, including provisioning of human dependent uses	Minor short-term impact associated with reduction in plant cover protecting soil, injury to and killing of non-target plants, and reduction in wildlife cover due to herbicide use. Negligible short-term impact to aquatic resources including salmonids. Impacts expected to decline to negligible as the area of management progressively reduced. (However, some management is expected to continue of newly discovered infestations). Cumulative minor to moderate positive impact over the long-term due to successful removal of invasive plants from small and large areas of initial infestation, and successful long-term restoration and maintenance of native species, communities, and ecosystem services.

3.0 Affected Environment

This chapter summarizes the relevant physical, biological, and social components of the ecosystem, some of which could be affected by actions associated with invasive plant management by Kodiak NWR. Portions of this description are drawn from Kodiak NWR's Revised Comprehensive Conservation Plan (USFWS 2008a), with exception of the section pertaining to invasive plants, which is a new addition. Readers are referred to this Plan for additional detail on the history, land status, environment, and human uses of Kodiak NWR.

3.1 Land Status

Kodiak NWR encompasses nearly 1.8 million acres within its legislative boundaries—the southwestern two-thirds of Kodiak Island, all of Uganik Island, and about 54,000 acres on Afognak and Ban islands. These islands, part of the Kodiak Archipelago, lie at the western edge of the Gulf of Alaska in southwestern Alaska. The approximately 30-mile wide Shelikof Strait separates Kodiak Island from the Pacific coast of the Alaska Peninsula. The City of Kodiak, site of Refuge headquarters, is about 250 air miles south of Anchorage and about 21 miles northeast of the Kodiak NWR boundary on Kodiak Island.

The legislative boundary of Kodiak NWR encompasses approximately 1,775,649 acres of land (Table 3.1). Of this acreage, approximately 8% is private land and 92% is federal land. Most (96%) of the private land is owned by three Native Corporations including Akhiok-Kaguyak, Inc., Koniag, Inc., and Old Harbor Native Corporation. Approximately 74% of the Native Corporation land is classified as Temporary or Permanent Conservation Easement. The Temporary Easement applies to a portion of Koniag, Inc. land and is subject to renewal consideration in 2012.

Table 3.1. Land status within Kodiak NWR.

Category	**Total**[1]
Fish & Wildlife Service	1,626,039
Other federal[2]	2,487
Native Corporation – Conservation Easement	104,691
Native Corporation – non-easement	37,314
Other private	5,118
Total	1,775,649

[1]All values in acres.
[2]Lands withdrawn as part of the Terror Lake Hydroelectric Project (FERC License No. 2743); the Service retains secondary management authority.

Administration of Kodiak NWR is based in Kodiak. We manage properties at five locations totaling 45 acres. Properties include the hangar site at the State airport; the headquarters site; and visitor center, apartment complex, and floatplane base sites in the City of Kodiak (Figure 2.2). Whereas Kodiak City sites are owned by the Service, headquarters and hangar sites are leased from the U.S. Coast Guard.

Alaska Maritime NWR encompasses nearly 336,000 acres within its legislative boundaries in the Kodiak Archipelago. In contrast to Kodiak NWR, most (98%) of the land in the legislative boundary is privately owned. The 4,595 acres of federal lands administered by Alaska Maritime NWR is comprised mainly of numerous (>400) small, widely scattered islands adjacent to the larger islands of the archipelago. These islands range in size from less than one-tenth acre to 1,407 acres (0.4 acre median size).

3.2 Physical Environment

The Kodiak Archipelago is 67 miles wide, 177 miles long, and encompasses a total area of 5,000 square miles. Kodiak Island, the largest (3,600 square miles) in the archipelago, is situated near the western border of the Gulf of Alaska between 56 degrees 30 minutes and 58 degrees 40 minutes north latitude and 150 degrees 40 minutes and 154 degrees 50 minutes west longitude.

Most of the archipelago islands are mountainous from interior to shoreline, the only exceptions being relatively flat floorsof glacial valleys and moderate relief on some glacial deposit aprons forming lowland shores, capes, and peninsulas. More subdued mountain topography characterizes the lowlands of southwestern Kodiak Island. The highest peaks in the Refuge are Koniag Peak and Mount Glottof, both more than 4,000 feet elevation. On the Afognak Unit of Kodiak NWR, 10 or more individual peaks exceed an elevation of 2,000 feet.

Drainages flow predominately northwest and southeast, following valleys deepened and straightened by glaciers in previous ice ages. The straits and elongated bays are fjords, representing former valleys over-deepened by ice to below present sea level. On Kodiak NWR, many elongated lakes occupy ice-scoured trenches, which are dammed by moraines. Except for the Dog Salmon River, Ayakulik-Red River system and Karluk River, which drain large glacial lakes, the island's rivers are small, short, and steep. They flow in valleys straightened by glaciers and end quickly in bays. Valleys are generally steep-walled, U-shaped, and have hanging tributaries. V-shaped and terraced canyons may be found where moraines have been breached or in areas where stream piracy or lateral diversion has occurred (as is common in a glacial landscape).

3.2.1 Climate

Kodiak NWR is within a maritime climatic zone. Temperature variations are generally small (except at higher elevations); humidity and precipitation are high; fog and clouds are frequent. At the State Airport in Kodiak, mean annual temperature is about 41 degrees Fahrenheit (°F) and mean total annual precipitation is 76.3 inches (1973 to 2004). Because of the warming effect of the Alaska Current (a northern eddy of the Japanese Current), the climate is warmer and wetter than nearby areas of interior mainland Alaska. Air temperatures seldom exceed 75° F in summer, or fall below 0° F in winter. Periods of subfreezing temperatures regularly occur from October through April; at higher elevations subfreezing temperatures can occur throughout the year.

Moist air is always present over the Kodiak Archipelago, brought in by the Aleutian low in the winter and by the continental low in the summer; precipitation occurs year-round. Near the City of Kodiak, more than 100 wet days (days on which 0.1 inch or more precipitation occurs) are expected per year, whereas most of Alaska, including Anchorage, has fewer than 50 wet days per year. The driest periods are late winter and mid-summer; but even then the probability of a wet day remains high (Johnson and Hartman 1969). Average precipitation on Kodiak Island varies with location. Due to the effects of mountains, precipitation level generally increases with altitude and differs substantially between the east and west sides of Kodiak Island. Total annual precipitation in the high peaks above Kiliuda Bay is about 115 inches, five times as much as the 23 inches on the Shelikof Strait side, at Karluk River, and Larsen Bay (Karlstrom and Ball 1969, Jones et al. 1978). The cool, wet climate of the archipelago means that lightning occurrence and lightning-ignited wildfires are rare.

3.2.2 Soils

Many factors affect soil composition and properties including parent material, topographic position, vegetation, and climate. Variation in these factors is considerable across the glaciated, mountainous archipelago area. The USDA Soil Conservation Service (now the USDA Natural Resources Conservation Service) surveyed soil and vegetation in northeastern Kodiak Island in the 1950s (Reiger and Wunderlich 1960). We expect that results from this survey are applicable to most of the Refuge area where similar parent material, landforms and vegetation occur. Well to moderately drained upland and valley soils consisted of four layers: a shallow litter-organic surface horizon overlaid on an ash layer, overlaid on silt loam (one-two feet thick), overlaid usually on coarse sand and gravel. Thickness of the ash layer was least on mountain slopes (foot or less) and greatest in valley bottoms (one to two feet). Permeability, a measure of water infiltration rate, was classified as moderate in the organic surface layer, rapid in the ash layer, and moderate in the silt loam subsoil. Generally, depth to the water table exceeded four feet in upland sites. In poorly drained (wetland) sites, water table depth ranged from zero to 24 inches. Wetland soils were classified as silt and clay loams on sites of poor drainage and peat on sites of very poor drainage.

The USDA Natural Resources Conservation Service (NRCS) is presently conducting soil surveys in the Kodiak Archipelago. Areas of survey focus include private land of Afognak Island, private and state lands in northeastern Kodiak Island, and private and federal land of selected watersheds within the legislative boundary of Kodiak NWR. One of the recently surveyed areas included Camp Island, Karluk Lake, where Kodiak NWR applied an IPM approach including herbicide to manage orange hawkweed infestation between 2003 and 2008. Preliminary soil survey results revealed three primary soil classes corresponding to different landform positions in areas covered by meadow and shrub vegetation (M. Mungoven, NRCS, pers. comm., Jan. 2010). Sites along the lake margin were classified as a shallow (18 in.) sandy-skeletal of rapid permeability. Moderately sloped sites above the lake margin classified a relatively deep (63 in.) loamy skeletal of moderately rapid permeability. Remaining upland sites dominated by herbaceous vegetation classified as a silt loam (24 in.) of moderate permeability over a loamy skeletal (35 in.) soil of moderately rapid permeability.

The NRCS also classified soil samples collected in 2006 by Kodiak NWR to facilitate IPM planning at Garden Island and Refuge Headquarters. The top 12 inches of soil at Garden Island was classified as a sandy loam. At Refuge Headquarters, sampling of the top 12 inches of soil revealed a well-drained loam with organic matter of 5 to 6% and neutral pH (6.8).

3.3 Biological Environment

Kodiak National Wildlife Refuge lies exclusively within the Kodiak Archipelago Ecoregion, one of 32 ecoregions in Alaska (Nowacki et al. 2001). This distinction is due to the large size of the archipelago area; its relatively unique climatic conditions; history of repeated, extensive glaciation except in a half-million acre relatively dry area of southwest Kodiak Island; and its limited diversity of native mammals. iota of the Kodiak Archipelago has been shaped by a unique combination of major physical and biological influences including glaciation; the 1912 Katmai ash fall; colonization and spread of Sitka spruce; and the recent introduction of non-native plants and animals (e.g., browsers and grazers such as Sitka black-tailed deer, Roosevelt elk, snowshoe hare, and mountain goat).

3.3.1 Vegetation

Since the current distribution of non-native plants is restricted to lower altitudes (less than 1,000 ft. elevation), our summary of vegetation is restricted to that zone. Vegetation cover differs across archipelago wildlands primarily due to variation in altitude, slope position, and soil characteristics. The four primary broad classes of vegetation cover in uplands and valleys consist of herbaceous graminoid-forb (e.g., meadow), deciduous shrub-tree, crowberry, and Sitka spruce. The crowberry class, where it commonly occurs in lowlands, is restricted primarily to southern Kodiak Island. Distribution of the spruce class is restricted mainly to Afognak Island and northeastern Kodiak Island. Most of the archipelago area is undeveloped wildland where vegetation comprises wholly native plant species. As of 2010, Kodiak NWR and its cooperators have catalogued more than 500 species of native vascular plants on lands of Kodiak NWR. Goals of Refuge management are to protect and conserve native plants and native plant communities (USFWS 2008a).

In areas subjected to routine human settlement, development, or use—including Refuge-administered properties in Kodiak—vegetation is usually composed of a mixture of native and non-native herb, shrub, and tree species. Parts of two properties administered by the Service include residential housing and associated lawns, gardens, and small plantings of non-native ornamental plants. Relevant to this assessment, goals of vegetation management on Refuge-administered properties in Kodiak are to maintain primarily native vegetation in undeveloped areas; to allow continued occurrence of non-native plants not considered highly invasive (e.g., clover, dandelion, pineapple weed, common plantain) on and immediately adjacent to developed sites; and to allow for vegetable gardens and ornamental plantings at residences so long as they do not include highly invasive species (USFWS 2007b; Gary Wheeler, USFWS, pers. comm., Feb. 2010).

Surveys conducted by the Refuge, in cooperation with the District, revealed that vegetation at most residential non-village sites in remote coastal areas consisted mainly of native vegetation with small areas occupied by non-native species including those associated with disturbed areas, vegetable gardens, and ornamental plantings. The same surveys also examined vegetation at two active and three inactive cannery sites within and adjacent to the legislative boundary of Kodiak NWR. Non-native plants commonly occurred at all canneries. At four of five canneries we documented infestations of one or more highly invasive species (orange hawkweed, oxeye daisy, creeping buttercup).

3.3.2 Invasive Plants

In Alaska, the most problematic invasive species are long-lived perennial herbs, shrubs, and trees (Carlson et al. 2008). As a group, these perennials typically propagate both by sexual and vegetative mechanisms. Moreover, new plants are produced both from germinating seeds and, following lateral extension of roots, from sprouting of daughter plants from node sites along roots (e.g., like strawberry). Additionally, most of these species are relatively shade-intolerant and consequently occupy mostly non-forested areas. Such areas are abundantly represented, comprising an estimated 71% of the land cover in the archipelago and 82% within the Kodiak NWR legislative boundary (Fleming and Spencer 2007).

Though many non-native species occur in the Kodiak Archipelago, relatively few demonstrate strong invasive tendencies—characterized by displacement of native plants and presumed alteration of community functional relationships (Carlson et al. 2008). Of the 113 non-native species ranked by Carlson et al. (2008), 37 are known to occur in the Kodiak Archipelago based on review of Refuge herbarium records and discussion with the District’s Noxious and Invasive Weed Coordinator (Table 3.2). Of these 37 species, 10 collectively occur on federal and private land within the legislative boundary of Kodiak NWR and on federal land of Alaska Maritime NWR.

Table 3.2. Non-native invasive plant species of the Kodiak Archipelago, invasiveness ranking[1], and occurrence on federal and private land within Kodiak NWR legislative boundary.

Species	**Invasiveness Rank[1]**	**Federal Refuge Land**	**Private Land**
Bohemian knotweed (*Polygonum X bohemicum*)	87		X
Giant knotweed (*Polygonum sachalinenesis*)	87		
Reed canarygrass (*Phalaris arundinacea*)	83		X
Orange hawkweed (*Hieracium aurantiacum*)	79	X	X
Canada thistle (*Cirsium arvense*)	76	X[2]	
European bird cherry (*Prunus padus*)	74		
Common toadflax (*Linaria vulgaris*)	69		
Siberian peashrub (*Caragana arborescens*)	64		X
Yellow alfalfa (*Medicago sativa ssp. falcata*)	64		X
Bull thistle (*Cirsium vulgare*)	61		
Oxeye daisy (*Leucanthemum vulgare*)	61	X	X
European mountain ash (*Sorbus aucuparia*)	59	X	
White clover (*Trifolium repens*)	59	X	X
Common dandelion (*Taraxacum officinale*)	58	X	X
Baby's breath (*Gypsophila paniculata*)	57		
Alsike clover (*Trifolium hybridum*)	57		
Common tansy (*Tanacetum vulgare)*	54	X	X
Timothy (*Phleum pretense)*	54	X	X
Tall buttercup (*Ranunculus acris*)	54	X	X
Creeping buttercup (*Ranunculus repens*)	54		X
Common chickweed (*Stellaria media*)	54	X	X
Red clover (*Trifolium pretense*)	53		
Orchard grass (*Dactylis glomerata*)	53		
Kentucky bluegrass (Poa pratensis)	52		
Foxglove (*Digitalis purpurea*)	51		X
Common sheep sorrel (*Rumex acetosella*)	51	X	
Black bindweed (*Fallopia convolvulus*)	50		
Curly dock (*Rumex crispus*)	48		
Common plaintain (*Plantago major*)	44	X	X
Common chickweed (*Stellaria media*)	42	X	
Dame's rocket (*Hesperis matronalis)*	40		
Shepard's purse (*Capsella bursa-pastoris*)	40		
Hempnettle (*Galeopsis sp.*)	40		
Lambsquarters (*Chenopodium album*)	37		
Common groundsel (*Senecio vulgaris*)	36		
Disc mayweed (*Matricaria discoidea*)	32		X
Corn spurry (*Spergula arvensis*)	32		

[1]Ranking derived by Carlson et al. (2008). Depicted ranking classes include: extremely invasive (>80), highly invasive (70-79); and moderately invasive (60-69); modestly invasive (50-59); weakly invasive (40-49). Maximum rank among 113 ranked species was 87.
[2]Alaska Maritime NWR.

With few exceptions we concur with the rankings derived by Carlson et al. (2008) for species documented in the archipelago. We do not concur with Carlson et al.'s (2008) ranking of creeping buttercup based on observations of its apparent displacement of native perennial forbs on undisturbed and minimally disturbed sites (W. Pyle, Kodiak NWR, pers. obs.; B. Brown, District, pers. comm.). We therefore consider it a highly invasive species in the Kodiak area. For similar reasons, we consider European mountain ash, common tansy, and splitlip hempnettle as highly invasive based on field observations by the District's Noxious-Invasive Plant Coordinator in the Kodiak Archipelago since 2004 (B. Brown, District, pers. comm.). The apparent increased invasiveness of these species may be attributed to more favorable climatic or soil conditions in the Kodiak area compared to interior areas of mainland Alaska.

Between 2005 and 2009, 10 highly invasive species were documented within the legislative boundary of Kodiak NWR, properties managed by the Refuge in Kodiak, or federal lands of Alaska Maritime NWR. Collectively, these species occur in 28 infestations at 19 sites including 10 sites on federal land and 9 sites on private land (Figure 3.1). Sixteen of 28 infestations are small, less than one-tenth acre, and the remaining 12 range in size from approximately one-tenth acre to an acre. Most (70%) of the infestations consist of two species, orange hawkweed and oxeye daisy. The four largest infestations occur primarily on private land. Three of these are composed of hawkweed (Camp Island area, Uganik Cannery, Zachar Bay Lodge) and one is composed of creeping buttercup (Akalura Cannery). Presently we estimate that the invasive plants collectively cover an area of five acres on 60 acres of land.

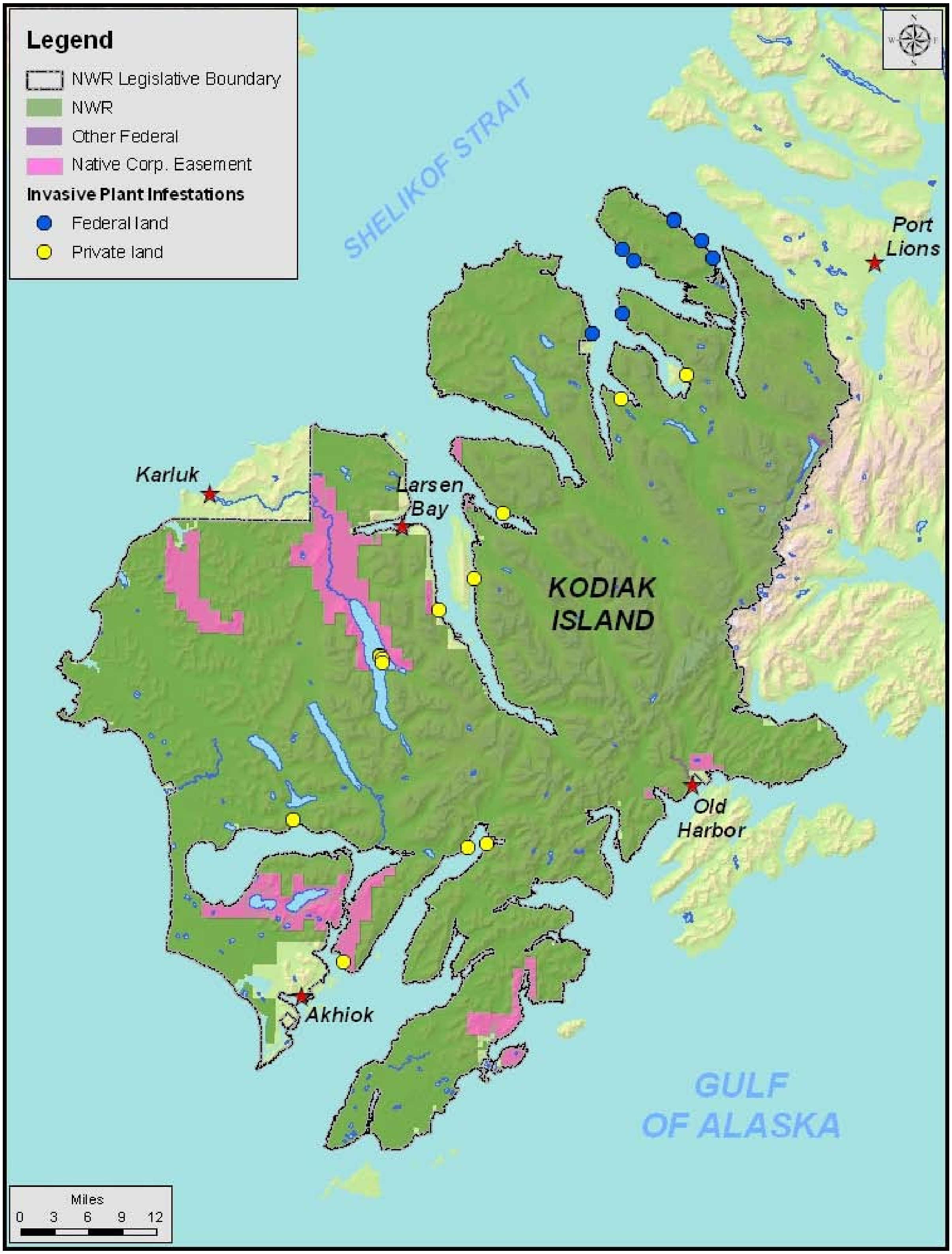
Non-native invasive species also occur on all Refuge-administered properties in the vicinity of the City of Kodiak. Of the four properties we administer, two harbor infestations of highly invasive plants including oxeye daisy at Refuge Headquarters and orange hawkweed at the Triplex apartment. Presently we estimate that invasive plants collectively cover an area of a quarter-acre on three acres of land.

Since 2003, the Refuge has developed considerable experience in management of orange hawkweed, oxeye daisy, and Canada thistle infestations. The following sections profile these projects and results.

3.3.2.1 Orange Hawkweed

We suspect that the infestation on the 48-acre Camp Island, Karluk Lake, was established in the 1970s from a single ornamental planting. After we recognized the problem in July 2002, we surveyed the island and estimated that hawkweed was the dominant herb cover on two acres. This infestation area included many infestation sites scattered across the island. Most sites were small but a few covered up to half acre.

Figure 3.1. Distribution of known infestation sites of highly invasive species in the legislative boundary of Kodiak NWR and on lands of Alaska Maritime NWR, Kodiak Island vicinity, Alaska.



Following an extensive evaluation, training, and authorization process we implemented an IPM Plan in May 2003 (USFWS 2003). We surveyed the area, flagged infestation sites, and applied a mixture of water, clopyralid herbicide, surfactant, and violet dye to hawkweed via backpack spray units in early June. In early September, we resurveyed the area and applied herbicide to any plants we missed in June application. We established permanent monitoring plots to assess response of hawkweed and native flora to herbicide and sampled these in May before herbicide application and in late July five-six weeks after application.

We implemented this protocol between 2003 and 2008. Moreover, every year we surveyed and marked infestation sites prior to herbicide application and sampled monitoring plots in late May and late July. In 2006, we found that we had consistently missed some plants with the late spring application because they were concealed by litter—typically previous years growth of grasses and ferns. Additionally, these same missed plants matured, flowered, and seeded potentially producing new plants in following years. In response to these concerns, we modified our approach in 2007. Our survey and marking effort became quite intensive with crews spending several days engaged in surveying infestation sites, clearing dead standing vegetation from the site, and marking the site perimeter. Additionally, we fielded crews between late July and September to survey the area for flowering hawkweed and remove, bag, and dispose of flowers. Annual surveys conducted since 2003 identified small hawkweed infestations on two nearby islands and Island Point on the mainland immediately south of Camp Island.

Monitoring results revealed that hawkweed was substantially reduced by annual treatments of Transline®, a clopyralid-based herbicide, between 2003 and 2008. Specifically, we estimated that hawkweed density declined 99% and frequency declined 86% (Figure 3.2). In response to hawkweed reduction, native vegetation increased and dominated former infestation sites by the end of 2005 (Figures 3.3 and 3.4). Total area annually subject to herbicide application declined from 3.5 acres in 2003 to 0.7 acres in 2008. Correspondingly, total annual use of clopyralid, the active pesticidal ingredient, declined 81%, from 23.1 fluid ounces in 2003 to 4.1 fluid ounces in 2008 (Figure 3.5). We anticipated it would take several years of herbicide application to reduce and eradicate hawkweed from Camp Island because the herbicide kills only live plants, the seed pool is presumed extensive, seeds remain viable for up to seven years (Jacobs and Weise 2007), and new plants are expected to germinate from seed.

3.3.2.2 Oxeye Daisy

We suspect that oxeye daisy, apparently contained in commercial wildflower seed mix, was inadvertently introduced to the Refuge Headquarters site when the area was seeded following facility construction in the early 1980s. Since establishment the infestation has increased and by 2005 it comprised the primary ground cover, along with moss and grass, in an acre of area surrounding the headquarters facility. Permanent monitoring plots established in 2005 indicated that foliar cover of oxeye daisy averaged

35% (range 22-52%). Cover of all other forbs collectively averaged 23% (range 13-38%).

In 2005 the Refuge initiated management of oxeye daisy at headquarters site. In early July we assembled 18 people, consisting of staff and volunteers, for a manual removal operation. We collected several large garbage bags of daisy from an area of 0.01 acres over a three-hour period. Results from before and after monitoring on the removal site indicated that manual removal, even at this labor-intensive rate (1.2 person hours/square meter), only reduced foliar cover of oxeye daisy from 52% to 28%. Evidently, some daisy roots were not removed, new plants sprouted from remnant roots, and daisy from the adjacent untreated area encroached into the treated area.

Following an extensive planning, training, and authorization process we implemented an IPM Plan in August 2007 (USFWS 2007b). In this area the primary IPM methods consisted of comparison of June and September herbicide treatments in different areas, removal of flowers during mid summer, mowing of the area before September herbicide treatment, and monitoring response of daisy to treatment on permanent plots. The herbicide aminopyralid (Milestone™VM) was selected for application and applied at the same rate in two different seasons along with surfactant (AGRI-DEX®) and colorant (ACMI Violet Dye®) to maximize herbicide efficacy and applicator efficiency. Foliar cover of oxeye daisy declined 80% the year following application of 3.8 ounces of herbicide to 1.54 acres (2.5 oz/acre) of infestation in the June treatment area. On the fall treatment area, foliar cover of oxeye daisy declined 100% the year following application of 3.1 ounces of herbicide to 1.26 acres (2.5 oz/acre) of infestation. This result persisted through 2009 as revealed in photos of permanent plots (Figure 3.6 and 3.7). In September 2008, we conducted a second application to remnant daisy patches. Herbicide use decreased 97% between applications, from 3.1 oz in September 2007 compared to 0.1 oz in September 2008.

Figure 3.2. Change in density of orange hawkweed on monitoring plots at Camp Island, Karluk Lake, following application of clopyralid herbicide between June 2003 and September 2008.

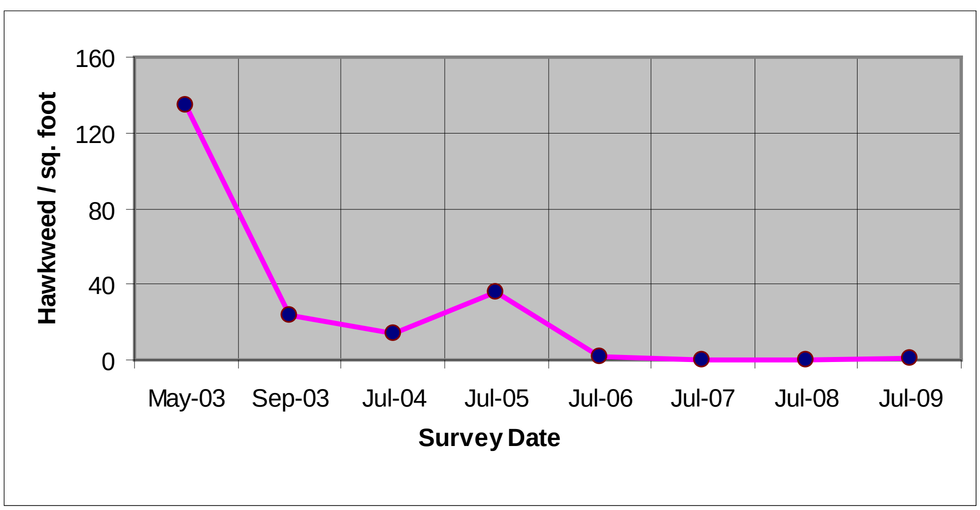
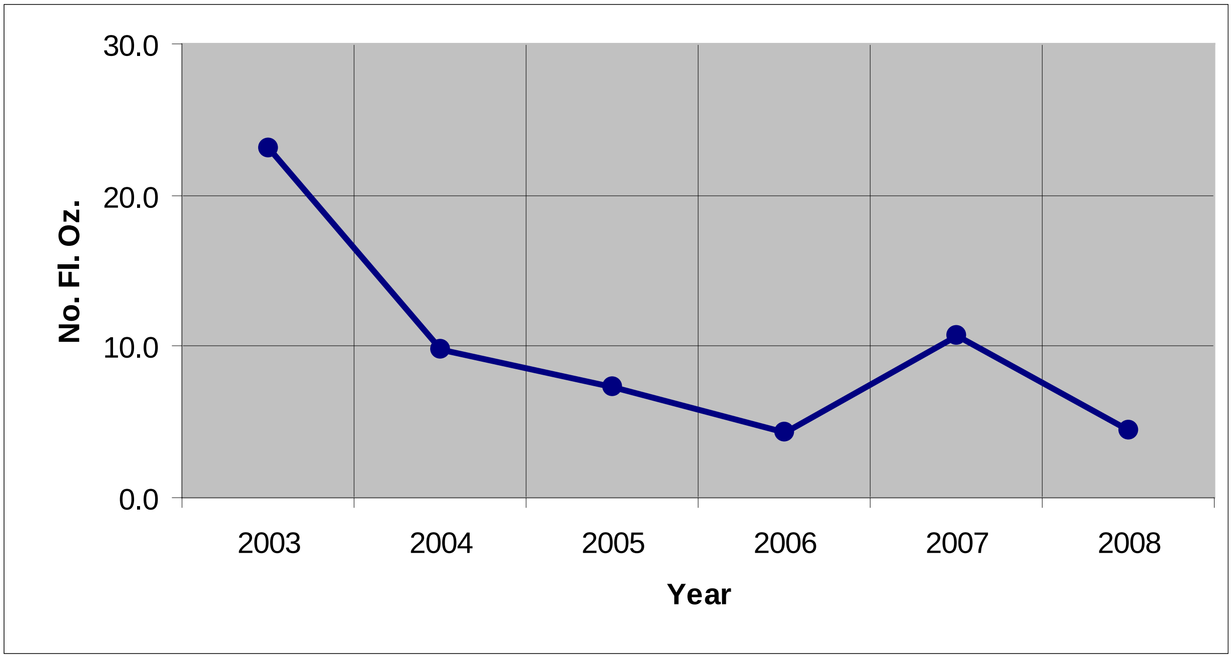


Figure 3.3. Orange hawkweed infestation at Camp Island, Karluk Lake, on 29 July 2002 before application of clopyralid herbicide.

Figure 3.4. Re-take (26 July 2009) of 2002 image following treatment (2003-2008) with clopyralid herbicide at Camp Island, Karluk Lake.

Figure 3.5. Total annual amount (fluid oz.) of clopyralid herbicide applied to orange hawkweed at Camp Island, Karluk Lake, 2003-2008.



3.3.2.3 Canada Thistle

In 2004, we were first notified of the thistle infestation at Garden Island by a concerned landowner from the Village Island area of Uganik Bay along western Kodiak Island. This small stand, which covered about 0.8 acres, apparently established back in the 1950s when the area was used as livestock pasture and the owner inadvertently used some hay contaminated with thistle seed.

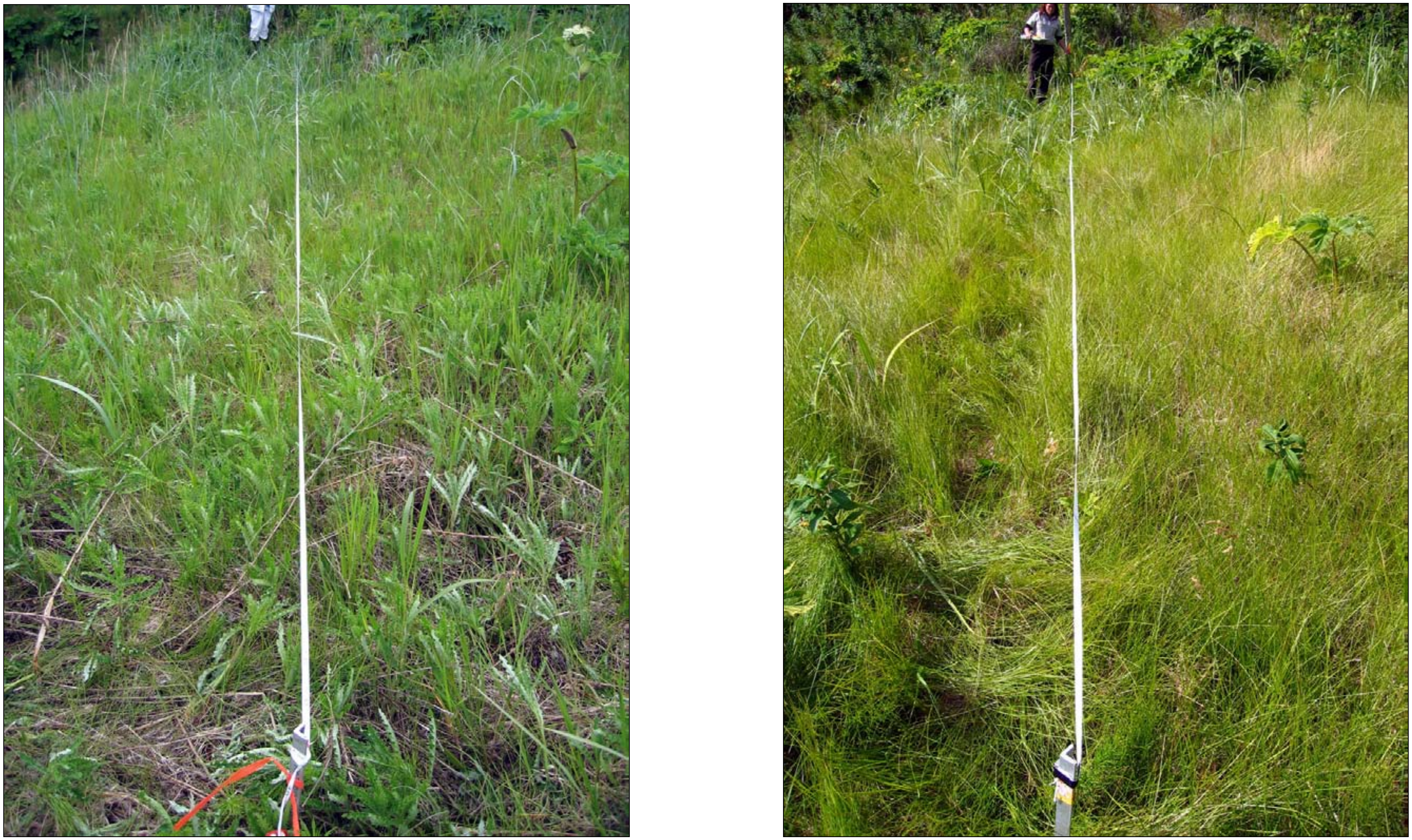
We initiated management in 2006. Our first action was to mow the thistle in mid August before seed set to eliminate potential seed spread. Following an extensive planning, training, and authorization process we implemented an IPM Plan in July 2007 (USFWS 2007a). In this area the primary IPM methods consisted of summer mowing to remove thistle flowering stalks and reduce thistle height growth followed by application of aminopyralid herbicide (Milestone™VM), surfactant (AGRI-DEX®) and colorant (ACMI Violet Dye®) following the first hard frost (e.g., usually late September).

Foliar cover of thistle declined 97%, from 9.9 stems/square meter to 0.3 stems/square meter, by summer 2009 following two aminopyralid applications (fall 2007 and 2008). In apparent response to thistle decline, grasses and forbs increased (Figure 3.8). Due to the reduction in thistle, aminopyralid use decreased 80% after the first application, from 2.0 oz in October 2007 compared to 0.4 oz in September 2008.

Figure 3.6. White-flowered oxeye daisy infestation at Refuge Headquarters Kodiak on 7 July 2007. Aminopyralid herbicide was applied to this infestation in late September 2007.

Figure 3.7. Photopoint depicting oxeye daisy infestation at Refuge Headquarters on 15 July 2009.

Figure 3.8. Canada thistle infestation at Garden Island, Uganik Bay, before (29 June 2006) and after (12 August 2009) applications of aminopyralid herbicide in fall 2008 and 2009.



3.3.3 Fish

There are 117 streams with approximately 329 stream miles that provide spawning and rearing habitat to one or more species of salmon in the legislative boundary of Kodiak NWR. In addition, there are 16 lakes, including Karluk Lake, ranging in size from 0.4-15.2 square miles that support spawning or rearing habitat of salmonids including Arctic char. Collectively, the freshwater salmon habitats on the Refuge are some of the most productive within ADF&G's Kodiak Management Area.

Salmon supported by Refuge habitats also sustain many people through subsistence, recreation, and commercial activities and indirectly through service and support industries to the fishers. The average commercial salmon harvest in the Kodiak Archipelago from 1982 through 2004 was approximately 18.7 million fish worth an ex-vessel value of 35.4 million dollars. Refuge-based salmon stocks comprised approximately 78% of total annual commercial harvest in the Kodiak Management Area (Brennan 2005).

3.3.4 Wildlife

Upland and wetland habitats provide food and cover for landbirds and aquatic migratory birds. Use of Refuge habitats is most intensive between April and October during the migration and nesting periods. We have recorded nesting by more than 100 bird species in the Kodiak NWR boundary. In general, nesting activity by landbirds and aquatic migratory birds occurs between May and August. A variety of landbirds—such as sparrows, thrushes, and warblers—nest and forage on or near the ground and are widely distributed in non-forested upland habitats of the Refuge.

Six mammal species are native to lands of Kodiak NWR including brown bear, red fox, river otter, ermine, little brown bat, and tundra vole. All of these species periodically occur in or near interior and coastal upland sites subjected to invasive plant management. Except for vole, most of the site use is short-duration for foraging or concealment purposes. In the case of river otter, its use of uplands is limited primarily to areas immediately adjacent to rivers, lakes, estuaries, and bays. The widely distributed often abundant tundra vole inhabits most upland habitats and is the species that most routinely occurs in uplands subject to invasive plant management. Brown bear tend to avoid areas near seasonally occupied residences where most invasive species occur and during the period when most active management has occurred. On the other hand, bear and fox frequent remote areas such as Camp Island and we have routinely observed both species walking through areas subjected to invasive plant management before and after active management operations have occurred.

Another nine nonnative mammal species were intentionally introduced to the archipelago between the 1920s and 1950s. Introduced mammals include Roosevelt elk, reindeer, Sitka black-tailed deer, mountain goat, snowshoe hare, pine marten, red squirrel, muskrat, and beaver. Elk and marten are restricted primarily to Afognak Island, goat is restricted to Kodiak Island, and other species are distributed in suitable habitat across most of the archipelago. Elk, goat, marten, red squirrel, muskrat, and beaver do not occur in any areas known to support invasive plants. On the other hand, field observations indicated that deer and hare have used areas that support invasive plants for foraging and, in some cases cover, including sites subjected to active management (e.g., Camp Island, Garden Island, Refuge Headquarters).

Some of the native and introduced mammals are highly valued as a source of meat in the case of subsistence, and as a source of sport, in the case of recreational sport hunting. Deer is the most harvested species followed by goat, elk, and brown bear. (ANILCA Section 810 Evaluation is in Appendix C).

3.3.5 Threatened and Endangered Species

No federally threatened or endangered species occur on Refuge lands except for Steller's sea lion. However, none of the remote and rocky primarily intertidal coastal sites sea lions use as haul-outs are known to support, or could support, highly invasive vascular plants. A federally threatened stock of northern sea otter commonly occurs in marine waters of bays and fiords adjacent to Kodiak NWR and Alaska Maritime NWR. Some of these otters may occasionally leave the water to rest on adjacent coastal rock outcrops. Federally threatened Steller's eider winter in some archipelago bays. Open ocean waters, and a few deep fiords, are seasonally used by endangered humpback, sei, and fin whales.

3.4 Human Environment

This section summarizes social, cultural, and economic conditions on lands and waters potentially influenced by invasive plant management in Kodiak NWR and Alaska Maritime NWR.

3.4.1 Economy

Commercial fishing and seafood processing, logging, recreational hunting and fishing, ecotourism, and U.S. Coast Guard expenditures make up the bulk of the economy of Kodiak. Several of these activities are based in towns and villages and, in the case of fish harvest, in nearshore and offshore marine waters adjacent to the archipelago. Subsistence and recreation are the primary economic uses of the Refuges. Because of the small size of invasive plant infestations, none are suspected of affecting the economy.

3.4.2 Subsistence Use

One of the purposes of the Refuges is to provide the opportunity for continued subsistence uses by local residents in a manner consistent with purposes of conserving fish and wildlife populations and habitats. Residents of Kodiak Island rely on and harvest an abundance and diversity of fish, game, invertebrates, and plants for subsistence purposes. Most subsistence activities occur near communities, along the coast and on lower reaches of major rivers where lands are often primarily in private ownership. The bulk of the subsistence use of Refuge lands is by residents of Akhiok, Karluk, Larsen Bay, and Old Harbor—the four nearest village communities. Estimated total annual subsistence harvest averaged 315 pounds per person and 90% of harvest was composed of fish, mainly salmon, and mammals, mainly deer (Scott et al. 2001). Plants composed 2% of the annual harvest.

Subsistence harvest also seasonally occurs at remote seasonal residences, which include private and federal lands in the Kodiak NWR boundary. (The 24 residences on Refuge land exclusively comprise facilities used to support shore-based commercial salmon fishers. This activity is regulated administratively through the Special Use Permit process). Subsistence use at remote residences is presumed to reflect a similar pattern of composition as described above with harvest emphasis during summer on fish, especially salmon, and salmonberries. (See ANILCA Section 810 Evaluation in Appendix C).

Since subsistence activity is mostly coastally based and focused near villages and outlying coastal sites, it overlaps the lowland area where most invasive plants occur. However, surveys conducted by the Refuge and its cooperators thus far indicated that invasive plants are an issue at very few sites, most of which are located in and adjacent to remote residences.

We have not observed any subsistence use of any of the areas subjected to invasive plant management by the Refuge between 2003 and 2008. Furthermore, we suspect that none of these areas actually received any subsistence use due to small size of the areas infested with invasive plants and, in the case of Camp Island, limited subsistence resources and high costs of access.

3.4.3 Recreational Use

The main recreation activities pursued by visitors on the Refuge are hunting for bear, deer, goat, and elk; fishing, and wildlife-viewing. Other activities include duck hunting, ptarmigan hunting, hiking, berry harvesting, beachcombing, sightseeing, photography, and snowmachining. Slightly more than half of visitors pursue their activities with the assistance of commercial guides who hold permits issued by the Refuge. Total annual recreation use-days averaged 8,262 on Kodiak NWR between 1997 and 2003.

Recreational use is relatively low on Refuge lands compared to other refuges accessible by road and is likely limited by high costs associated with boat and floatplane transport. Existing use is greatest at coastal sites accessible by boat, and coastal and interior sites accessible by floatplane, such as sheltered bays, lakes, and a few places in the largest rivers.

Many recreational visitors base their activities out of lodges, temporary guide camps, and public use cabins. (The Refuge maintains nine public use cabins that provide good all-weather camping). Distribution of recreation is also highly seasonal and related to site accessibility. Hunting is a major use and most occurs in late fall. Fishing, another major use, is focused on salmon in a few reaches of a few accessible large rivers, and where rivers empty into bays. Bear-viewing, a third major use is focused primarily at a few readily accessible river and coastal sites.

We are not aware of any areas that harbor highly invasive plants and support significant recreational use. However, we have observed some hiking use of Garden Island by residents of the nearby Village Islands area.

4.0 Environmental Consequences

The purpose of this chapter is to identify, describe, and compare the ecological and human health impacts of the alternatives. We apply the following organizational framework. Impacts of alternatives on issues identified in the scoping process and most of the resources described in the previous chapter are addressed under one of three broad subject areas: physical environment, biological environment, and human environment. We assign level of impact (negligible, minor, moderate, major) in accordance to the type, duration, intensity, and area affected by a management practice. We also evaluate the potential cumulative impacts or effects of multiple management actions potentially conducted at many sites over a period of years. Much of the following information pertaining to herbicide effects was derived from risk assessments prepared for the USDA Forest Service by Syracuse Environmental Research Associates, Inc. (SERA 2003, 2007; see http://www.fs.fed.us/foresthealth/pesticide/risk.shtml) and incorporated through reference as identified in 43 CFR 46.

4.1 Physical Environment

4.1.1 Impacts from Alternative 1 to Soils

Absent management, existing infestations of invasive plant species would increase in area and spread through adjacent suitable habitats within and between the Refuges and private lands. Additionally, new infestations would more readily establish and spread in the absence of outreach, survey, coordination, and prevention actions.

Soil composition, chemistry, and fauna are affected by invasive plants. For example, orange hawkweed is thought to attain competitive advantage by co-opting soil fungi that symbiotically interact with, and augment nutrition of, native perennial plants (L. Wilson, British Columbia Ministry of Agriculture and Lands, pers. comm.). Displacement of native vegetation by invasive plants, as depicted in Figures 3.3 and 3.4, would likely change and potentially degrade soil faunal diversity, productivity of soil biotic interactions, infiltration, and protection from erosion.

Presently, the area occupied by invasive plants on Refuge lands and adjacent private lands is small and the impact to soils is considered negative and minor. However, the impact to soils is expected to change from a negative and minor in the short-term to negative and major in the long-term as the area of infestation expands. We estimate that invasive plants would spread and occupy perhaps 1,000 acres over the next 20 years, 10,000 acres in 30 years, and 50,000 acres in 50 years. We believe this estimate is plausible for three primary reasons: (1) Refuge lands support more than 100,000 acres of lowland non-forested habitat (Fleming and Spencer 2007), much of which we consider suitable for establishment and growth of one or more highly invasive plants; (2) the area of suitable habitat would likely increase due to climate change and the associated increase in mean temperature of air and soil; and (3) invasive plant populations would, after an initial lag, increase at exponential rates until all suitable habitats are occupied (Radosevich 2007).

Cumulative Effects: Absence of invasive plant management would cause minor short-term negative impacts to soils and associated physical and biological components and processes. Net impacts to soils would increase from minor in the short-term to major over the long-term due to the exponential increase in the areal extent of infestation. Soils would be increasingly impacted by type conversion from native plants to invasive perennial herbs and shrubs.

4.1.2 Impacts from Alternative 2 to Soils

Soils would be directly impacted by application of manual methods, but level of effect would differ substantially among classes of invasive species and size of infestation. Effects would be negligible where manual methods were used to remove invasive trees. Specifically, it is assumed that most species of invasive shrubs and trees (e.g., European mountain ash, Siberian pea shrub) would be readily killed by cutting or girdling the main stem. In contrast, effects would be greatest where manual methods were used to remove rhizomatous perennial invasive herbs (e.g., hawkweed) and shrubs (e.g., knotweed). Level of effect of manual methods applied to this class would correspond to infestation size and number of years requiring treatment. Impact would be negligible in small infestations comprised of a few plants. In such cases, individual plants would be dug and soil would be excised to facilitate removal of invasive plant roots. In larger infestations, many people would be required to successfully remove invasive perennial herbs or knotweed and it would take repeated effort over many years into the future, with the distinct possibility that the job would never be complete. In this case, impacts to soil would be moderate and limited in scope to the immediate infestation site but would be long-term. Experience acquired by Refuge staff and the Park Service on such removal projects indicated that most sites would require multiple treatments because removal of all invasive plant roots is seldom achievable (USNPS 2008). In most cases, successful removal of invasive plant roots would require complete removal and disassociation of the topsoil and intermingled roots of all plants. Removal of topsoil would tend to dehydrate it and probably adversely impact soil fauna in and immediately below the topsoil. Topsoil removal, disassociation, replacement, and trampling by personnel involved in the operation would probably reduce infiltration and increase potential for erosion for the duration of the treatment and some time thereafter.

Cumulative effects. The combined applications of all manual methods to all invasive species infestations over a period of years would cause minor negative impacts to soils and associated physical and biological components and processes in the short-term. This is because of the limited area (less than 50 acres) where manual methods would be applied to manage highly invasive species on the Refuges. Unfortunately, impacts to soils would increase from minor to moderate over the long-term due to the increase in size of the largest infestations associated with the likely failure to control with manual methods. Moreover, soils would be increasingly impacted by type conversion from native plants to invasive perennial herbs and shrubs.

4.1.3 Impacts from Alternative 3 to Soils

Effects of manual methods would differ between Alternative 2 and 3. Impacts would be consistent with those described in Alternative 2 where manual methods would be applied to manage small infestations of invasive plants. With respect to larger infestations, the impacts of manual methods would decrease from minor and short-term to negligible and temporary. This result is attributed to a substantial reduction in physical disturbance to soils and the removal of the soil and soil fauna altering traits of the invasive plants through management with chemical methods instead of manual methods.

Because chemical herbicides would be used primarily to manage the larger infestations, chemical-specific effects could impact soils. Soils also are the key medium in which chemicals applied to manage invasive plants may be translocated offsite via percolation through soil to ground and surface waters. We address potential impacts associated with proposed chemical use to control infestations of highly invasive plants below.

Although herbicide would be applied directly to invasive plants, it may also be applied to the soil surface between invasive plants. Some of the herbicide applied to plant and soil surfaces would leach into soil subsurface, particularly water soluble compounds such as aminopyralid. Because some species of soil microbes metabolize aminopyralid, these species could temporarily increase where aminopyralid leached into soil (SERA 2007). Rate of degradation is related to rate of microbial activity which is heavily influenced by (soil and air) temperature. Aminopyralid is considered moderately persistent in soil with a half-life average of 40 days. A half-life is defined as the time it takes for 50% of the chemical to degrade to other compounds.

Effects of Aminopyralid were evaluated in a risk assessment performed by the U.S. Forest Service (SERA 2007). Results of bioassays conducted in compliance with herbicide registration concluded that soil microorganisms and earthworms were not adversely affected when these were subjected to labeled application rates. Potential for offsite loss was characterized as a negligible risk where aminopyralid use was restricted to labeled application rates and stipulations.

In contrast to aminopyralid, glyphosate has a different action and effect in soils (SERA 2003). Glyphosate degrades via microbial action in upland soils and via microbial action and photolysis in aquatic environments. Glyphosate either has no effect or tends to increase soil microbes or microbe activity. None of the study results indicated any long-lasting or deleterious effects on soil ecology. Because this compound readily binds with soil organic matter, high organic matter content in soil will reduce the probability that the chemical will move offsite via water percolation through soils. Potential for offsite transport and dispersal of glyphosate also is influenced by post-application rainfall. In the Kodiak area, offsite movement may occur where moderate to heavy rain occurs in the weeks immediately following application. Despite such a possibility, there was no indication that limited offsite movement adversely affected non-target plants following ground-based low volume applications. In sum, such applications would negligibly and temporarily affect soil ecology following application.

Cumulative Effects. The impact of combined IPM actions conducted at multiple sites over a period of years would be minor, short-term and negative. Effects are expected to be highest in the first few years with continued treatment of previously managed sites combined with initial treatment of new sites. Low level of impact is expected because of the relatively small area that would be subject to management. Level of negative impact would be expected to decline from minor and short-term to negligible and temporary in correspondence to progressive reduction in the total area of infestation subject to management. Negative impact is not expected to decline completely because surveys would likely reveal new infestations that would require additional management.

4.1.4 Impacts from Alternative 1 to Water Quality

Herein we apply the same assumptions about expected future changes in vegetation composition and structure that we applied in Section 4.1.1. Absent management, the area of non-forested lowland invaded and dominated by highly invasive species would exponentially increase over time. These changes in plant composition and structure would indirectly and adversely affect water quality. Where shallow-rooted invasive plants, such as hawkweed, replaced deep-rooted native perennial plants in uplands, especially native graminoids, potential for soil erosion and waterway sedimentation would increase. Reed canarygrass could replace woody riparian shrubs and trees, alter stream channel morphology, and increase stream temperature (Lavergne and Molofsky 2004, Fierke and Kauffman 2006). Bohemian knotweed could replace riparian vegetation, change channel morphology, and reduce stream productivity (Urgenson et al. 2009).

Currently we consider the ecological impact as negligible given the very limited area (e.g., about five acres) known to be occupied by any highly invasive species on Refuge lands. Absent management, it is highly likely that abundance and distribution of highly invasive species would substantially increase over the long-term. The level of impact would change from negligible in the short-tem to a moderate negative influence over the long-term and as a consequence, exert increased indirect influence on aquatic systems.

Cumulative Effects: Currently we consider the impact negligible given the very limited area collectively occupied by highly invasive species within and near the Refuges. However, impact would change from negligible to a moderate negative influence over the long-term as the area of invasive plant occupation and indirect influence on aquatic systems increased.

4.1.5 Impacts from Alternative 2 to Water Quality

Application of manual and mechanical methods would negligibly influence water quality over the short-term. Potential would be low for topsoil to erode and flow into surface waters due to minimal soil disturbance associated with removal of invasive plants of small infestations located in upland settings, even when repeated removals were required over a period of years. However, treatment of large infestations would potentially cause minor short-term impact. This would be attributed to a substantially increased potential for soil erosion due to the increase in the area of disturbance associated with removal of topsoil and invasive plant roots. Additionally, topsoil would need to be disturbed repeatedly over a period of years to ensure complete removal of rhizomatous perennial invasive herbs and shrubs. Slope pitch and density of vegetation following invasive removal also would influence erosion potential. Finally, the probability that eroded sediment would enter and temporarily degrade water would be related to distance between the treatment area and water body. Treatment of infestation areas closest to water bodies would have greatest potential to produce sediment that could affect water quality.

Cumulative effects: The impact of combined actions conducted at multiple sites over a period of years would be minor and negative. This consequence is attributed mainly to limited area where application of manual methods would potentially increase soil erosion and consequent sedimentation into adjacent water bodies. Impact level would remain relatively consistent because the area subject to treatment would not appreciably change as defined by an unknown upper limit of funding and personnel available to support treatment of the largest, highest priority sites. Because these solely mechanical efforts would likely fail, the area requiring treatment would eventually exceed available resources and invasive species would increasingly dominate vegetation composition. We would expect water quality to be adversely affected where vegetation density decreased and soil erosion potential increased following type conversion from native to non-native invasive species.

4.1.6 Impacts from Alternative 3 to Water Quality

Effects of manual methods would differ between Alternative 2 and 3. Impacts would be consistent with those described in Alternative 2 where manual methods would be applied exclusively to manage infestations comprising a few invasive plants (e.g., 10 or fewer per infestation area). With respect to larger infestations, the impacts of manual methods would decrease in Alternative 3 from minor, short-term negative effect to a negligible, short-term effect. Soil erosion and sedimentation potential would be substantially reduced in Alternative 3 because we would not severely disturb soil and protective vegetation cover to remove invasive plant roots. Instead, herbicide would be used to kill invasive plants while leaving most of the cover of non-target plants intact with one exception. On sites where invasive species dominate ground cover, killing the invasive species with herbicide could temporarily remove most of the protective ground cover of vegetation. In such a case, potential for erosion and sedimentation would temporarily increase then decline as cover of non-target vegetation increased.

Potential for contamination and degradation of water quality are influenced by many factors including infestation size, herbicide type, application rate and method, proximity to water, soil composition, and rainfall following application. The herbicides proposed for use in this alternative are not expected to substantially degrade water quality, as discussed below.

It is improbable that aminopyralid applications would measurably degrade water quality due to herbicide properties and application location, type, and method. Aminopyralid is considered to be of exceptionally low toxicity to invertebrates and vertebrates (SERA 2007). Consequently, even if aminopyralid reached surface waters, the amount would be small, it would be rapidly dispersed, and it would be unlikely to cause any acute or chronic impairment of invertebrates and vertebrates. As described under soil impacts, aminopyralid would only be applied to small infestations (less than one-acre) in uplands. Any residual herbicide that reached the soil surface would be retained and biodegraded within the upper 12 inches of soil. Potential for offsite egress of the herbicide would be further minimized by adherence to label requirements and best safety practices. Potential for contamination of water via airborne drift of small droplets of herbicide, leaching to groundwater, or surface and subsurface runoff would be minimized by restriction to directed foliar backpack spray application, spray tank pressurization sufficient to achieve large spray droplet size, prohibition on spray application within 10 feet of water bodies, and application to dry sites when wind was minimal.

Glyphosate would be used to manage invasive species unaffected by aminopyralid (e.g., grasses). It also would be used to manage any invasive species at sites that occur adjacent to surface water (e.g., reed canarygrass). Like aminopyralid, potential for water contamination would be low due to herbicide properties and application location, type, and method. We would use directed foliar backpack sprayer, cut-stem, or injection methods of application as appropriate. In contrast to application of aminopyralid, application of glyphosate would be allowed for formulations registered for use near and over water. Mobility and transport of residual glyphosate would be limited because most would bind with organic matter and sediment in soils and water. Residual herbicide would be mostly dissipated and biodegraded within two months in upland soils and within two weeks in water (SERA 2003). Area subject to potential influence would be limited to infestation sites. Additionally, the potential for water quality degradation would decline through progressive reduction of infestation and application area. Glyphosate use would be limited to commercial formulations that did not contain the surfactant POEA (i.e., polyethoxylated tallow amine), which has been shown to be toxic to some aquatic organisms. However, we would add a surfactant such as AGRI-DEX® to promote glyphosate efficacy. AGRI-DEX® is the least toxic of the glyphosate-compatible surfactants to aquatic organisms and fish studied to date (Monheit 2004, Snyder-Conn 2006).

In summary, proposed uses of herbicide would result in a minor, short-term negative effect. However, this effect would decline to a negligible level corresponding with rapid reduction in size of infestations and herbicide usage in years following initial herbicide application, as discussed in Chapter 3 and demonstrated in the Refuge's history of herbicide use in management of orange hawkweed, Canada thistle, and oxeye daisy.

Cumulative Effects. The impact to water quality from multiple actions conducted at multiple sites over a period of years would be negligible. This consequence is attributed mainly to limited projected area of treatments; limited mobility of residual herbicide in the environment; minimal toxicity of herbicides to invertebrates and vertebrates; fairly rapid dissipation and biodegradation of herbicides; and the application of best management practices to minimize risk of exposure and contamination. Though we are uncertain how much area may require application of glyphosate, we suspect it would be minimal based on current knowledge of the type and extent of invasive plant infestations. Since most documented infestations occur in uplands, it is likely that new infestations also would occur primarily in uplands and few would occur in seasonal or semi-permanently flooded sites. Despite expected success at reduction and elimination of currently known infestations, we suspect that new infestations would be identified and some would require treatment with herbicide. We therefore conclude that herbicide use could be required over the long-term and that water quality would continue to be negligibly affected. Because of the success at treatment, we do not expect that infestations would increase and adversely affect potential for soil erosion and sedimentation.

4.2 Biological Environment

4.2.1 Impacts from Alternative 1 to Vegetation

Kodiak Island supports an abundance of lowland non-forested habitat potentially suitable to establishment and spread of highly invasive species. Absent management these species would increase in distribution, abundance, and ecosystem influence as described in Section 4.1.1. On the most suitable sites, highly invasive species would eventually displace native vegetation. Increased displacement of native vegetation would result in the alteration of plant community composition, structure, and ecosystem functional relationships. Though knowledge is limited about influence of these species on functional relationships, much is known of their influence on community composition and structure. Type conversion from native to mainly invasive species has been documented on Kodiak Refuge, as depicted in Figures 3.3 and 3.4; in some wildland areas adjacent to residential areas near Kodiak and Port Lions, many other areas of

Alaska (USNPS 2009), and the Pacific Northwest (Fierke and Kauffman 2006, IPCBC 2008, Urgenson et al. 2009).

Currently we consider the ecological impact as negative and minor given the very limited area known to be occupied by any highly invasive species within the Refuges. However, impact would change from minor to major over the long-term where any of the species substantially increased in distribution and abundance. Absent management, it is highly likely that such increases would occur over the long-term.

Cumulative Effects: Presently, highly invasive species have a minor negative impact on vegetation of the Refuges. Collectively these infestations comprise about five acres of Refuge lands. However, the collective area of invasive plant infestation is expected to substantially increase over time absent management as referred to in Section 4.1.1. This trend of increase would cause the level of net impact on vegetation to change from minor and negative over the short-term to major and negative over the long-term.

<u>4.2.2 Impacts from Alternative 2 to Vegetation</u>

Vegetation would be directly impacted by application of manual methods but level of effect would vary primarily in relation to density and size of infestation coupled with the level of mixture of invasive and non-target plants. Effect would be negligible where manual methods were used to remove invasive trees. Specifically, it is assumed that impacts would be negligible where infestations of invasive shrubs and trees (e.g., European mountain ash, Siberian pea shrub) were limited to a few individuals that minimally affected surrounding vegetation. In contrast, effect would be greatest where manual methods were used to remove rhizomatous perennial invasive herbs (e.g., hawkweed) and shrubs (e.g., knotweed), a result confirmed by the collective experience of Refuge staff engaged in manual treatment of low and high density infestations. Level of effect of manual methods applied to this class would correspond to infestation size and number of years requiring treatment. Impact would be negligible in small infestations comprising few plants. In such cases, individual plants including roots would be dug; however, seeds may remain in the surrounding soil. Adjacent non-target plants would be removed or injured as needed to facilitate complete removal of invasive plants. In larger infestations, the effect would be moderate because many people would be required to successfully remove invasive perennial herbs at a site, which would take repeated effort over many years, with the distinct possibility that the job would never be complete. As noted above, experience acquired by Refuge staff and the Park Service on such removal projects indicated that removal of all invasive plant roots is seldom achievable (USNPS 2008). It would take several years for non-target vegetation to recover from severe disturbance following treatment. In such cases, we would injure and kill some non-target plants because, in most cases, invasive plants would be intermixed with non-target plants and successful removal of invasive plant roots would require topsoil and non-target plant removal, disassociation, replacement, and trampling by personnel involved in the operation.

Cumulative Effects. The combined applications of all manual methods to all invasive species infestations over a period of years would cause minor short-term negative impacts to non-target vegetation. This consequence is attributed mainly to limited area where manual methods would be applied to manage highly invasive species on the Refuges. However, negative impacts would increase from minor to moderate over the long-term due to the likely failure to eliminate or contain the larger infestations which would tend to displace native species and dominate the landscape.

4.2.3 Impacts from Alternative 3 to Vegetation

Effects of manual methods would differ between Alternative 2 and 3. Impacts would be consistent with those described in Alternative 2 where manual methods would be applied to manage infestations comprised of a few invasive plants (e.g., 10 or fewer per infestation site). With respect to larger infestations, the impacts of manual methods would decrease from a minor short-term negative effect to a long-term positive effect. This result would be attributed to: (1) greater likelihood of successful site restoration through the use of herbicide, in conjunction with manual methods that would not severely disturb soil; (2) and an increase in non-target vegetation following decrease in invasive plants following treatment.

Because chemicals would be used primarily to manage the larger infestations, chemical-specific effects would differentially affect non-target vegetation. In general, herbicides would be applied to reduce and eliminate invasive plants and to increase native plants. The net effect would be a moderate, though localized, long-term impact in areas subject to treatment. This outcome is substantiated by results of invasive plant management projects operated by the Refuge and profiled in Chapter 3 (USFWS 2003, USFWS 2007a, USFWS 2007b). Below we address differential impacts associated with proposed herbicides.

In general, impacts of herbicide application would be minor and short-term to non-target vegetation in treatment areas. Impacts would be minimized by reliance on ground-based herbicide applications targeted to invasive plants. Despite such regulated application, some herbicide would be inadvertently applied to non-target plants and soil surface where invasive and non-target plants were intermixed. With respect to the herbicide aminopyralid, most non-targeted broad-leaved forbs, but not grasses, would be injured or killed where it was applied to foliage or absorbed by roots (SERA 2007). In the case of glyphosate, most forbs and grasses would be injured or killed where it was applied to foliage (SERA 2003). Because glyphosate is relatively immobile in soil, absorption by roots of non-target plants would be unlikely.

Non-target native vegetation could also be adversely impacted inside and outside a treatment area by spray drift during herbicide application. However, potential for spray drift would be minimized by use of directed ground-based application methods and adherence to herbicide label requirements and stipulations that address drift considerations. SERA (2007) concluded that potential for offsite movement (drift, runoff, or wind erosion) and potential for offsite impact to non-target vegetation were insubstantial for aminopyralid except in areas of hard-packed clay soil. Similarly, SERA (2003) characterized risk of glyphosate and concluded that potential for impact by drift or runoff was negligible and not related to soil type. We found no evidence to indicate that offsite losses of either herbicide type could occur via transport through plant roots.

Cumulative Effects. The net effect of multiple IPM actions conducted at multiple sites would be negative and minor over initial years of treatment. Some non-target vegetation would be injured or killed and therefore adversely affected where it was intermixed with invasive plants and herbicide was inadvertently applied to both. However, the scope of the impact would be negligible because of the limited area subject to management, use of a directed foliar application method, targeting of application primarily to foliage of invasive plants, and herbicide selectivity in the case of aminopyralid. Level of impact would be expected to shift from negative, minor, and short-term to positive, moderate, and long-term in response to progressive reduction in the area of invasive plant infestation and the corresponding increase and maintenance of non-target vegetation. These benefits would substantially outweigh the expected negligible impact from continued treatment of newly discovered infestations.

4.2.4 Impacts from Alternative 1 to Wildlife

Native vegetation is a key component of wildlife habitat on Refuge lands. Absent management, highly invasive species would increasingly replace native vegetation and alter the composition and structure of native plant communities, as addressed in Section 4.2.1. Though some wildlife species could benefit from an increase in highly invasive species, most would not. As the area dominated by highly invasive plants increased, the level and scope of impact to many wildlife species would change from negative, minor, and small-scale currently to negative, minor, and large-scale within 50 years.

Abundance of vertebrates (e.g., voles, bears, landbirds, etc.) and diversity of invertebrates (e.g., insects) would decline as the area of infestation of highly invasive plants increased and replaced food and cover provided by native plants in meadow, shrubland, and riparian areas. Animals that could not find cover and forage in infestation sites would seek other areas. This could increase interspecific and intraspecific competition for resources, decrease nutritional condition, and reduce survival and abundance. To the extent that populations of prey species like voles were negatively influenced, populations of primary predators such as fox and ermine would also be negatively influenced.

Cumulative Effects: Non-management of highly invasive plants would substantially influence wildlife and habitat of Refuge lands. Cover and food resources important to wildlife, including keystone species such as brown bear, would be affected. Currently, the total area of infestations is small, and the net effect on wildlife and their habitat is considered negative and minor. As the area of infestation inevitably increased, the scope and level of impact would increase and affect more species and a larger portion of each species' population. We conclude that the net effect on wildlife and their habitat of the Refuges would be major and significantly adverse within the next 50 years.

4.2.5 Impacts from Alternative 2 to Wildlife

Application of individual manual and mechanical treatments would negligibly and, in many sites, temporarily affect wildlife. This assessment is based on several factors including relatively small size of infestations, limited duration of treatment operation at most sites, and limited influence of treatment on wildlife habitat resources found in infestation sites. Animals that would be affected least would be those with the largest seasonal home ranges exemplified by deer and bear. Individuals of either species would not rely to any significant degree on food and cover resources within such small areas occupied by currently known infestations. Nonetheless deer and bear may be temporarily displaced where they occurred within or near an infestation site at the time of treatment.

In contrast, the smaller animals, particularly tundra vole and songbirds, would be affected most by a treatment. Yet it is likely that even these taxa would be substantially affected only in the case of treatment of the larger infestations (e.g., exceeding one-tenth acre). Effect would consist primarily of displacement due to relatively prolonged human activity in the treatment area, possibly ranging over several days in each year of treatment. In the case of small songbirds, some may nest in the infestation area and these nests could fail due to disturbance. Birds that foraged in the treatment area could also be displaced during the time of treatment. In the case of voles, it is likely that they would be influenced most by destruction of habitat associated with removal of topsoil, as required for removal of perennial invasive plant roots. Due to this disturbance, voles living in treatment areas would be displaced to adjacent area and fitness may be compromised by increased competition.

Cumulative Effects. The combined applications of manual and mechanical methods of treatment to all invasive species infestations over a period of years would cause negligible short-term impacts and minor to moderate long-term negative impacts. Initial impact would be minimal because the treatment would influence a relatively small portion of the total wildlife habitat encompassed by the Refuges. Beneficial effects to wildlife over the long term would occur in those areas where infestations are controlled and eliminated. However, negative impact would increase to minor and eventually to moderate over the long term in correlation with the gradually increasing area where the vegetated component of wildlife habitat shifted from dominance by native species to dominance by invasive plant species. This type conversion outcome would result from the likely eventual failure of manual and mechanical methods to control and contain the larger invasive plant infestations, such as the orange hawkweed infestation that originally occupied almost four acres of Camp Island on Karluk Lake.

4.2.6 Impacts from Alternative 3 to Wildlife

Effects of manual methods would differ between Alternatives 2 and 3. Impacts would be consistent with those described in Alternative 2 where manual and mechanical methods would be applied to eliminate infestations comprising a few invasive plants (e.g., 10 or fewer per infestation area). With respect to larger infestations, the impacts of Alternative 3 would consist of a minor, temporary negative effect eventually replaced by a minor, long-term positive effect. Such a result would be attributed primarily to the change in vegetation composition induced by treatment. In contrast to Alternative 2, infestation treatment in Alternative 3 would not include short-term degradation of habitat associated with manual removal of topsoil and vegetation to facilitate removal of invasive plant roots. Vegetation composition, a primary constituent of wildlife habitat, would be disrupted and altered by implementation of either alternative. Extensive application of manual methods (Alt. 2) or a combination of manual and herbicide methods (Alt. 3) would reduce cover and forage used by invertebrates, landbirds, and mammals following treatment. However, these declines would be minimal since infestation sites will likely have experienced substantially less usage compared with similar non-infested sites (i.e., the infestation would have already reduced usage, so the additional effect of treatment is less discernible). Whereas decline in wildlife food and cover would persist under Alternative 2 due to likely failure to eradicate an infestation, it would not persist under Alternative 3. In sites where native meadow plants composed the potential natural vegetation, recovery would be rapid for non-target native plants, especially graminoids, as was witnessed following the Refuge's use of herbicide to remove orange hawkweed from meadows at Camp Island, Karluk Lake. It is unlikely that this recovery would require human-augmented plantings, with the exception of sites like Kodiak NWR Headquarters with a semi-natural composition of vegetation, because treatment sites would be relatively small and native vegetation would be abundant in the vicinity of infestation sites. At the headquarters site, we would need to augment recovery by seeding native vegetation, as was successfully demonstrated with a 2009 planting.

Use of herbicides can pose a hazard and risk to wildlife, especially when the formulations used are known to have high toxicities. Additionally, relative effects of toxicant ingestion may be substantially greater in secondary consumers (e.g., predators such as weasels) compared with primary consumers (e.g., herbivores such as voles). Under the proposed alternative, we acknowledge that wildlife might be affected by herbicide use. However, we estimate that the effects would be insubstantial for the following reasons:

- The herbicides chosen will be limited to those regarded as least toxic, relatively low persistence, and limited mobility following application;
- Low volumes of herbicide will be applied directly to foliage via backpack sprayers;
- Substantial decline (more than 80%) in herbicide use is expected in successive treatments with eventual cessation of herbicide use at any given infestation site; and;
- The relative size of infestation areas is small; few presently exceed more than an acre.

Review of the technical literature indicated that the effects of aminopyralid and glyphosate have been studied on invertebrate and vertebrate animals (SERA 2003, 2007). Testing of herbicide effects on animals typically involves species that are readily propagated and manipulated for experimental purposes. Moreover, the governing assumption is that the range of species subject to evaluation is representative, in terms of physiological processes, of taxonomically related species. Consequently, results from studies of aminopyralid toxicity on rats, mice, rabbits, and dogs are extrapolated to other mammal species (SERA 2007). To assess animal responses to field conditions (e.g., application of the herbicide in the field), results from toxicity studies are further modeled and evaluated in exposure studies that examine potential effects of different direct and indirect exposure scenarios that may result from different types of application plus worst-case scenarios involving spillage.

Though limited in scope, results from toxicity and exposure studies indicated that aminopyralid is virtually non-toxic, non-carcinogenic, non-mutagenic, and non-teratogenic (SERA 2007). Furthermore, none of the studies indicated that aminopyralid adversely affected mammals, birds, aquatic or terrestrial invertebrates, or terrestrial microorganisms. Due to this result, Milestone™VM, an aminopyralid-based commercial herbicide formulation, was classified as a "Reduced Risk" herbicide by the U.S. Environmental Protection Agency (EPA). In accordance with that agency's standards, Milestone™VM has "low-impact on human health, low toxicity to non-target organisms (birds, fish, and plants), low potential for groundwater contamination, lower use rates, low pest resistance potential, and compatibility with Integrated Pest Management."

Effects of glyphosate would differ from aminopyralid. Many of the toxic effects reported for glyphosate apparently are attributed to additive chemical surfactants contained in commercial formulations registered for use in terrestrial upland areas (SERA 2003). Under this alternative, none of the glyphosate commercial formulations containing surfactant compounds would be used. Tu et al. (2001) and SERA (2003) reviewed results from studies of glyphosate effects. Both reviewers concluded that glyphosate was minimally toxic to birds, mammals, and invertebrates and unlikely to directly or indirectly impair animal health, particularly when applied at low volumes via backpack-applied directed foliar spray. Birds and mammals exposed to high volumes of glyphosate underwent weight loss indicative of potentially impaired food-processing ability. A study that examined glyphosate influence on deer foraging found neither aversion to glyphosate-sprayed foliage nor reduction in rate of plant consumption (Sullivan and Sullivan 1979). Due to the tendency of residual glyphosate to bind with soil and sediments, it is unlikely that it would be transported from upland sites to water bodies and ingested by wildlife.

Cumulative Effects. The combined applications of IPM methods of treatment to all invasive species infestations over a period of years would cause negligible short-term negative impacts and minor to moderate long-term positive impacts. Initial impact would be negligible because the treatment would influence a relatively small portion (less than a thousandth) of the total wildlife habitat encompassed by the refuge. The negligible impact would result from reduction of wildlife food and cover for one to two years following herbicide application to a very small portion (less than a thousandth) of the Refuge's wildlife habitat. Additionally, birds and mammals would be temporarily disturbed and displaced by activity of personnel engaged in field operations at treatment sites. Herbicide effects would be negligible due to the small size of treatments, low herbicide volumes, directed ground-based application methods, and, the low toxicity and limited mobility and persistence of aminopyralid and glyphosate. Negligible short-term negative impacts would be replaced by minor to moderate long-term positive impacts as wildlife food and cover were restored at treatment sites.

4.2.7 Impacts from Alternative 1 to Aquatic Resources

The productivity of aquatic habitats is closely linked to the composition and productivity of vegetation in adjacent riparian areas. In turn, the productivity of aquatic habitat can influence its capacity to provide cover and food for resident and anadromous fishes, as well as fish eaters, such as river otter and belted kingfisher. Aquatic habitat productivity also can be influenced by sediment runoff from upland areas. Upland areas with diverse, dense, and deep-rooted vegetation are presumed to be less erosion-prone than areas with monotypic shallow-rooted vegetation.

Streambank vegetation can regulate the morphology of channels of low gradient streams; extent of stream shading provided by undercut banks and overhanging vegetation; quantity of nutrients (e.g., nitrogen); and the composition and availability of terrestrial insects for fish. Aquatic habitat quality would decline where highly invasive species with affinity to riparian and wetland habitat (e.g., reed canarygrass, creeping buttercup, Bohemian knotweed) replaced native herbs, shrubs, and trees along lakeshores, streams, and rivers. Presently, the area infested by each highly invasive species is small and the impact to aquatic resources is considered negligible. Over time, the impact would increase as infestations expand, with the most pronounced impacts associated with invasive species such as reed canarygrass and Bohemian knotweed. A few acres occupied by either of these species would constitute a major adverse impact. This potential exists given the presence of these species on or near Refuge lands and the absence of any invasive plant management under this alternative.

The effect of invasive species on riparian and wetland habitats would be related to type and abundance of invasive species. Whereas creeping buttercup may only replace native herbs, reed canarygrass and Bohemian knotweed may replace native herbs, shrubs, and trees (Lavergne and Molofsky 2004, Urgenson et al. 2009). Displacement of native plant communities would have the greatest impact to aquatic habitat. With reed canarygrass and invasive knotweed shrubs, such degradation is variously characterized by alteration of stream morphology and reductions in recruitment of native herbs and riparian shrubs and trees; stream shading; in-stream woody-debris for fish cover; diversity and supply of invertebrate food to fish; and stream productivity (Lavergne and Molofsky 2004, Fierke and Kauffman 2006, Urgenson et al. 2009).

Cumulative Effects: Absent management, highly invasive species will increase in area and extent of impacts as described in Section 4.1.1. The net effect on aquatic resources would be a change from the current negligible impact to a major negative impact wherever native vegetation of riparian areas and wetland is invaded and replaced by highly invasive species. Additionally, negative impact would be compounded by increased erosion and sediment runoff associated with replacement of native upland vegetation by invasive species.

4.2.8 Impacts from Alternative 2 to Aquatic Resources

Implementation of Alternative 2 would result in a negligible short-term effect to fishery resources in the vicinity of infestation sites. Application of manual and mechanical methods would increase potential for erosion and sedimentation where efforts were made to manage the largest infestations. Erosion potential would be influenced by infestation size and the area subject to removal and disassociation of topsoil, as required for removal of roots of perennial invasive plants.

Cumulative Effects. The combined applications of manual and mechanical methods of treatment to all invasive species infestations over a period of years would cause negligible short-term impacts and minor long-term negative impacts. Initial impact would be minimal because the treatment would influence a relatively small area, the bulk of which consist of terrestrial habitat. Impacts would consist of increased potential for erosion and sedimentation associated with soil removal and disassociation required for invasive plant removal. However, impact would increase to minor and negative over the long-term in correspondence with gradually increasing area where terrestrial and riparian habitat shifted from dominance by native species to dominance by invasive plant species. This type conversion outcome would result from indirect effects to aquatic habitat quality associated with the likely eventual failure of solely manual and mechanical methods to control the largest invasive plant infestations.

4.2.9 Impacts from Alternative 3 to Aquatic Resources

Impacts would be consistent with those described in Alternative 2 where manual and mechanical methods would be applied to eliminate infestations comprised of a few invasive plants (e.g., 10 or fewer per infestation area). With respect to larger infestations, the impacts of Alternative 3 would consist of a negligible and temporary negative effect and a minor to moderate long-term positive effect. This assessment is based on several factors including the relatively small size of infestations, limited duration of treatment operation, and limited influence of treatment on aquatic habitat resources near and adjacent to infestation sites. Although herbicide would be used to manage the larger infestations, it is unlikely that herbicide would measurably degrade aquatic habitat resources.

Herbicides used to treat terrestrial vegetation have the potential to enter water bodies and affect aquatic organisms through direct application into aquatic environments (of herbicides approved for use in these habitats), through accidental spraying (via aerial or ground applications), or through the movement of herbicides from upland areas to nearby water bodies via groundwater, surface runoff, or subsurface runoff.

The primary factors that determine the potential influence of herbicides on aquatic resources include herbicide type, herbicide volume, application method, mobility and dissipation of residual herbicide, and location of application in relation to water bodies. Review of bioassay and toxicity studies pertaining to aminopyralid revealed no indication of toxicity to aquatic invertebrates and fish (SERA 2007). Under this alternative, none of the glyphosate commercial formulations that contain surfactant compounds would be used, such as those registered for use only in upland terrestrial sites. SERA (2003) reviewed results from bioassay and toxicity studies of glyphosate and concluded that commercial formulations that did not contain surfactant were minimally toxic to aquatic invertebrates and fish. Stehr et al. (2009) evaluated effects of glyphosate (no surfactant) on fish development and found no impairment to growth or reflexes. Neither aminopyralid nor glyphosate are known to bioaccumlate in fatty tissues of organisms (SERA 2003, 2007).

Addition of a non-ionic surfactant is recommended to enhance efficacy of aquatic-registered glyphosate, such as Aquamaster®. Under this alternative, the least toxic surfactant would be used in conjunction with glyphosate. Presently AGRI-DEX® surfactant is known as the least toxic to fish and other aquatic resources (Smith et al. 2004). In a scenario where a 2.5% solution of surfactant with herbicide, it was estimated that direct application of AGRI-DEX® to water would result in toxicity to rainbow trout at water depths of five mm or less. At depths greater than 5 mm, no adverse effects were detected, probably because of dilution of the surfactant in greater water volume.

Contributing factors expected to minimize the effect of herbicide on aquatic resources include directed ground-based application methods and limited mobility and relatively rapid dissipation of residual herbicide (SERA 2003, 2007). In most cases, herbicide would be applied to invasive plant infestations in terrestrial upland environments. Potential for offsite movement of aminopyralid would be further minimized by adherence to label stipulations and by prohibition of application within 10 feet of any water body. In contrast, we would apply aquatic-use registered glyphosate to treat infestations of invasive species that could not be controlled with aminopyralid or, could be controlled, but occurred on sites where aminopyralid use would be prohibited. Where operating in riparian and wetland contexts, entry to water could occur and aquatic organisms including fish could be exposed to residual glyphosate and surfactant. However, it is unlikely that effects would be detrimental given low toxicity of glyphosate and surfactant; rapid dissipation in water; rapid adsorption by suspended and bottom sediments; and relatively rapid biodegradation (SERA 2003, Smith et al. 2004).

Cumulative Effects. The combined applications of IPM methods of treatment to all invasive species infestations over a period of years would cause negligible short-term negative impacts and minor to moderate long-term positive impacts to aquatic resources. Initial impact would be negligible because combined treatments would affect a relatively small portion (less than a thousandth) of the area encompassed by the Refuges, and most of the treatments would be restricted to terrestrial uplands. The negligible impact would consist of potential entry and circulation of trace amounts of herbicide and surfactant into water inhabited by salmonids and their prey. However, potential for exposure would be minimized by conservative application practices, low volume application rates, and relatively rapid dissipation and biodegradation of chemicals. Over the long-term, aquatic resources would benefit from management under this alternative to the extent that native vegetation was successfully restored on the larger infestation sites. This benefit would increase from minor to moderate through time in direct relationship to the area that could have been occupied by highly invasive species had the alternative not been implemented.

4.3 Effects on the Human Environment

4.3.1 Impacts from Alternative 1 to Worker Safety and Health

No impacts would occur because invasive plants would not be subject to any management action.

Cumulative Effects:

No cumulative impacts would occur because invasive plants would not be subject to management action.

4.3.2 Impacts from Alternative 2 to Worker Safety and Health

Effects on human health and worker safety would be negligible and temporary. Travel to remote sites via floatplane or boat would represent a type of potential direct hazard. The Refuge owns and operates two floatplanes and a fleet of boats to facilitate travel to remote locations; otherwise we charter commercial floatplane services. These vehicles are operated by employees or businesses extensively trained and certified for floatplane or boat operation. Vehicle operators are responsible for the safety of passengers. Additionally, passengers are required to adhere to safety standards specified by the vehicle operator.

Actions associated with manual methods of invasive plant management may include digging, cutting, sawing, scything, stooping, and lifting. Actions associated with mechanical methods of invasive plant management may include use of motorized weed trimmers in field sites and Kodiak facility sites, and a brush-cutter drawn by a small tractor at Refuge facility sites in Kodiak. Potential manually induced injuries could include sprains, strains, blisters, and cuts to hands, arms, knees, and backs. Potential mechanically-induced injuries could include being struck by flying debris, cuts, burns, sprains, and strains. Direct hazards associated with manual and mechanical methods are readily predicted and controlled. Worker safety would be ensured by adherence with manufacturer product safety standards, as appropriate, job hazard analyses, and training of employees in equipment use, and provision of appropriate safety equipment.

Cumulative Effects. A combination of management actions at all sites over time would result in a negligible temporary impact. This assessment is based not only on the relatively low risk of management operations, but also on the limited scope and frequency of management. Scope of management would be collectively limited to a small number of infestation sites, initially less than 40, and limited total area of infestations, initially less than 60 acres. Actions would be relatively infrequent and of limited duration, perhaps a week for the largest projects, and furthermore restricted to the period between May and October. Provision of training and adherence to safety standards would minimize the probability of risk and injury.

4.3.3 Impacts from Alternative 3 to Worker Safety and Health

Effects described in Alternative 2 would also apply to Alternative 3 with respect to management of small infestations managed entirely with manual and mechanical methods. Although these methods also would be applied to manage large infestations, the scope would be substantially limited primarily to removal of invasive plant flowers; mowing at the headquarters site; clearing dead standing non-target vegetation from the vicinity of invasive plants; and cutting non-target shrubs to facilitate access to invasive plants growing amidst shrubs.

Large infestations would be managed with an IPM approach that included allowance for herbicide use. The types of worker activities associated with herbicide use would include:

- Transportation between the headquarters storage site and a field storage site (e.g., administrative units) or between the headquarters storage site and the field mixing site;
- Mixing chemicals with water in a backpack spray tank;
- Walking over uneven terrain with a loaded backpack sprayer weighing between nine and 34 pounds (i.e., weight of one to four gallons plus equipment);
- Applying herbicide directly to foliage with backpack sprayers, or by dabbing herbicide on cut shrub and tree stems, or by injecting herbicide into shrub stems;
- Cleaning and maintaining application equipment; and
- Disposal of disposable PPE such as Tyvex® coveralls, commercial herbicide containers, and broken application equipment.

There are specific direct risks associated with the handling and use of herbicides in general, in addition to the physical risk associated with the application process (e.g., walking with a loaded backpack sprayer over uneven terrain). The types of injuries that may result from improper or accidental exposure to herbicide proposed for use in this alternative are described below.

Aminopyralid is considered virtually non-toxic to mammals including humans (SERA 2007). Moreover it is considered non-carcinogenic, non-mutagenic, and non-teratogenic. The primary hazard to workers involves potential aminopyralid exposure to skin, eyes, and lungs through direct contact with liquid or inhalation of vapors. Skin and lung exposure are not known as health risks. Eye contact is known to cause moderate irritation. Tests of accidental oral ingestion indicated that most was rapidly excreted in unchanged form. SERA (2007) concluded that there was "…no basis for suggesting that adverse effects are likely in either workers or members of the general public even at the maximum application rates…"

Much more is known of glyphosate effects than aminopyralid effects because the former has been in use for the past 30 years, while the latter has been in use for less than 10 years. Like aminopyralid, glyphosate also is considered to be of low toxicity to mammals including humans, and has been assessed as non-carcinogenic, non-mutagenic, and weakly teratogenic (SERA 2003, Monsanto 2005). The primary hazard to workers would involve potential contact of liquid to skin and eyes, and inhalation of vapors. Exposure may cause moderate irritation—in the case of eye exposure the irritation level is similar to detergent exposure. Reviews conducted by SERA (2003) concluded that there was "…very little indication of any potential risk at the typical application rate of 2 lbs. of active ingredient per acre. Even at the upper range of plausible exposures in workers, most hazard quotients are below the level of concern."

The Refuge acquired considerable experience in the storage, transport, and use of herbicides between 2003 and 2008. No accidents occurred and safety standards were met and exceeded. Worker safety was ensured by routine application of standards for transportation, storage, and use described in:

- Labels and Material Data Safety Sheet (MSDS) for commercial herbicide formulations;
- Job Hazard Analysis;
- Integrated pest management plans; and
- Pesticide use proposals.

Potential hazards were further minimized by routine maintenance of application equipment, supervision and training of applicators by a certified pesticide applicator, applicator use of additional personal protective equipment (PPE), and provision of first aid equipment at treatment sites. Under this alternative we would adopt the same suite of operational standards and practices to minimize exposure and risk of herbicide storage, transportation, and use. Based on this assessment we conclude that use of an IPM approach allowing for judicious use of herbicide would have a minor temporary negative effect on worker safety.

Cumulative effects: The combined applications of the IPM approach allowing for herbicide use to all invasive species infestations over a period of years would cause minor temporary negative impacts to worker safety and health. This assessment includes consideration of a few workers that may be repeatedly exposed to both of the proposed herbicide types at multiple project sites over a period of years. The two types of herbicide proposed for use are among the least toxic known and consequently the inherent level of health risk to workers is minimal and readily mitigated through full compliance with worker training requirements, herbicide label stipulations, and agency standards for safe herbicide storage, transportation, use, and disposal.

4.3.4 Impacts from Alternative 1 to Public Safety and Health

No impacts would occur because invasive plants would not be subject to any management action.

Cumulative Effects:

No cumulative impacts would occur because invasive plants would not be subject to management action.

4.3.5 Impacts from Alternative 2 to Public Safety and Health

For the purposes of this section, we detail potential effects of alternatives to safety and health of public and non-public. As described here, public consist of visitors engaged in subsistence or recreational use of the Refuge lands or those visiting the headquarters facility in Kodiak. Non-public consist of Refuge employees, contractors, and cooperators engaged in work on Refuge lands; employees who reside in Refuge-owned apartments; Refuge salmon set-net permittees and family who occupy private residences at 24 sites on Refuge land; and seasonal and permanent residents of private land, in cases where owners request the District and Refuge to undertake control operations on those sites.

Implementation of Alternative 2 would have a negligible temporary effect on public and non-public uses. This alternative involves the same type and scope of management activities and related potential hazards as described in 4.3.2 under worker safety with the exception of field transportation concerns. The potential for injury to public and non-public would be minimal since they, unlike workers, would not be involved in the management activity. To further minimize potential safety risk, entry and access to infestation sites on public land would be temporarily closed during, and for a brief period after, the operation of the management activity—both to facilitate safety of public and non-workers. In the case of activities undertaken in Kodiak, office staff would be notified of plans and requested to avoid facility grounds or residential sites during activity operation. At Refuge-owned and private residences, the operation would be coordinated with residents to minimize hazards and interference.

Cumulative Effects: A negligible temporary effect would result from the combined effects of management at all infestation sites over a period of years. In contrast to workers directly engaged in management activities, public and non-public would not be readily exposed to the activity because they would have no role in it. Furthermore safety and health risk would be minimized by notifying public and non-public of site management plans, and by closing or requesting avoidance of sites during management operations. (See ANILCA Section 810 Evaluation in Appendix C).

4.3.6 Impacts from Alternative 3 to Public Safety and Health

Impacts to safety of public and non-public uses would be consistent with those described in Alternative 2 where manual and mechanical methods would be applied to eliminate infestations comprised of a few invasive plants (e.g., 10 or fewer per infestation area). With respect to larger infestations, the impacts of Alternative 3 also would consist of a negligible temporary effect. This assessment is based on several factors including the relatively small size of infestations and the very low potential for direct or indirect exposure to herbicides proposed for use. Direct contact could consist of contact of herbicide liquid to skin and eyes or inhalation of herbicide vapors. Indirect contact could consist of ingestion of vegetation, meat, or water containing herbicide residue.

Since public and non-public would not be involved in management activities, the main sources of potential health risk would be direct contact with herbicide on infestation sites immediately following herbicide application, exposure from ingestion of contaminated vegetation, meat, or water. Skin exposure would be the most likely hazard for people accessing sites where herbicide was recently applied. We would prevent this type of inadvertent exposure by notifying public, employees, and non-public of site management plans. Additionally, we would close public places to entry and access during and immediately following herbicide application for a period specified on the herbicide label. In the case of private lands, we would coordinate with landowners and recommend the same standard of access and re-entry restriction of residents and their pets.

Low volume, small-scale, and ground-based direct foliar applications of aminopyralid and glyphosate proposed for use under this alternative would pose insubstantial direct or indirect risk to public and non-public safety. Regarding aminopyralid, a review of exposure and bioassay testing concluded that "for members of the general public, upper bounds of hazard quotients at the highest application rate are below a level of concern by factors of 100 to 125,000 for longer term exposures", and that "…there is no basis for suggesting that adverse effects are likely in either workers or members of the general public even at the maximum application rate…" (SERA 2007). Regarding glyphosate, review of exposure and bioassay testing concluded that "the risk characterization for both workers and members of the general public are reasonably consistent and unambiguous. For both groups, there is very little indication of any potential risk at the typical application rate of 2 lbs. a.i./acre [i.e., 2 lbs. of the active pesticidal ingredient per acre]. Even at the upper range of plausible exposures in workers, most hazard quotients are below the level of concern" (SERA 2003). Risk would be further minimized by use of commercial glyphosate formulations without additive surfactants such as polyethoxylated tallow amine (POEA). The toxicity of this surfactant is considered greater to mammals than glyphosate. When used in combination, glyphosate with POEA would likely increase the level of health risk to public and non-public, though overall levels would still be considered low (SERA 2003).

The public could be indirectly exposed to herbicide when they harvested and consumed fish, wildlife, or plants contaminated with herbicide. Under this alternative it would be highly improbable that public health would be jeopardized because most infestation sites would receive limited public use due to high costs of access; the collective area of infestation would be very small compared to the total refuge area; herbicide would be applied to invasive species and only incidentally applied to intermixed non-target vegetation, none of which would be consumed by people; and there would be very limited application of herbicide during the season when the public is harvesting game.

Potential health risk associated with consumption of contaminated fish or water would also be extremely low. Contamination of waters and fishes would be highly unlikely with aminopyralid applications restricted to upland infestation sites. Though this herbicide is fairly mobile, most would be assimilated by sprayed plants and biodegraded in soils of the application area. Moreover there are no documented instances of significant non-accidental offsite movement to water sources following ground-based applications (SERA 2007). Nonetheless, if such loss did occur, the amount would be extremely low and the chemical would be diluted and biodegraded in water. Due to the extremely low toxicity of aminopyralid, human intake of trace aminopyralid in fish or water would not pose a health risk (SERA 2007). Furthermore, most of the ingested trace amounts of aminopyralid would be rapidly excreted in human waste and not be assimilated by tissues and organs.

Glyphosate may be applied to manage certain species of highly invasive plants that could not be managed with aminopyralid, and otherwise it could be used on the same invasive species as aminopyralid but in sites where aminopyralid use was prohibited, such as riparian areas and wetlands. Some of the glyphosate applications could occur directly over water. In flooded wetland sites the potential for glyphosate entry into water would be high. In riparian sites the potential would be low where soil was dry, moderate where soil was saturated and high where soil was flooded. Potential for heath risk associated with human intake of contaminated water or fish would be negligible for the following reasons. We would restrict glyphosate use to commercial formulations registered for broad-spectrum use, including aquatic sites. Upon contact with soil, most residual glyphosate would rapidly bind to soil sediment and biodegraded in situ. Upon contact with water, residual glyphosate would rapidly dilute, bind to suspended and bottom sediment, and biodegrade. Such binding would substantially reduce the potential for ingestion of residual glyphosate by fishes or organisms that served as fish food. Nonetheless, it is plausible that trace amounts of glyphosate could be ingested and assimilated into fish, the fishes could be harvested and eaten by humans, and contaminated water could be drunk by humans. Due to extremely low potential for human ingestion of trace residual glyphosate coupled with its low toxicity, we conclude that health risk would exist but that it would be insubstantial.

Cumulative Effects: The combined applications of an IPM approach allowing for herbicide use on all invasive species infestations over a period of years would cause negligible temporary impact to public and non-public safety and health. This assessment includes consideration of cumulative direct and indirect effects associated with potential for exposure to residual herbicide. The two types of herbicide proposed for use are among the least toxic known and, consequently, the inherent level of health risk to public and non-public is minimal and readily mitigated through compliance with temporary site access restrictions, herbicide label stipulations, and agency standards for safe herbicide storage, transportation, use, and disposal.

4.4 Conclusion

We rejected Alternative 1 for the following reasons. We are required by law, policy, and purposes to manage invasive plants on National Wildlife Refuges. Consistent with legal requirements, we are required to prevent and minimize the impact of human factors, such as invasive species, that can impinge upon the integrity, function, and productivity of natural evolutionary, ecosystem, and successional processes.
The ecological and economic impacts of invasive plant species are well understood (USFWS 2008, Pimental et al. 2004). Likewise, we sufficiently understand the high potential for adverse impacts associated with the highly invasive plant species of greatest concern to Kodiak NWR (Carlson et al. 2008, USNPS 2009). Moreover, many state governments of the U.S. and provincial governments of Canada recognize these same species as major pests capable of inflicting extensive ecological damages and economic costs.

Implementation of Alternative 2, which relies solely on manual and mechanical methods, may effectively eliminate small infestations of most invasive plants. Attempts would be made to control and contain all infestations of the 15 highly invasive species known from the area within the legislative boundary of Kodiak NWR, Refuge properties in Kodiak, and on lands of Alaska Maritime NWR in the Kodiak Archipelago. Presently known infestations of all species occupy a total of 5 acres distributed over 28 areas and 60 acres of land, substantially less than a thousandth of the total area encompassed by the Refuges (1.8 million acres). In cooperation with the Kodiak Soil and Water Conservation District, we could also provide technical support of management operations outside the Refuge boundary as requested and approved by the landowner.

Review of environmental consequences indicated that implementation of Alternative 2 would entail negligible safety and environmental risks in the short term. However, this strategy would inevitably fail due to the difficulty of control of large infestations of perennial invasive herbs and shrubs and limited availability of funding and personnel resources to simultaneously manage all infestations. Due to this outcome, invasive species would increase and achieve a level of abundance that was unmanageable. Consequent impacts would shift from negligible in the short-term to minor in the mid-term to moderate in the long-term in proportion to increases in the area dominated by highly invasive plant species and the corresponding decrease in the integrity and quality of native fish, wildlife, and plant habitat.

Alternative 3 would adopt an IPM approach. This could include the same manual and mechanical methods as are included under Alternative 2, but would allow for directed herbicide use in the appropriate situations. This approach is consistent with the approach adopted by the Fish and Wildlife Service nationally and with all pertinent federal laws and policies. Small infestations consisting of 10 or fewer invasive plants per infestation area would be managed exclusively with manual and mechanical methods. Larger infestations would also be managed with these methods, potentially in conjunction with herbicide. Impacts associated with implementation of this alternative would be minor and negative in the short-term chiefly due to the low level safety risks and minor ecological effects associated with limited herbicide use. However, negative impacts would decline to a negligible level within 10 years due to successful control of infestations and consequent reduction in herbicide usage. Over the long-term, Refuge resources would benefit from management under this alternative to the extent that expansion of existing infestations was prevented, and that native vegetation was successfully restored on the larger infestation sites. This benefit would increase from minor to moderate through time in direct relationship to the area that could have been occupied by highly invasive species had the alternative not been implemented. This outcome would be realized despite the probability that IPM management would need to continue, albeit at very low levels, to address newly documented infestations. Potential for discovery of undocumented infestations is relatively high for two reasons. Most of the Refuge vicinities have not been surveyed, particularly uninhabited coastal and lake sites. Also, some invasive plant infestations may have been, or may be, introduced via common seasonal public and commercial use originating from Kodiak or Port Lions, towns with large and long-established populations of orange hawkweed, as well as scattered, small populations of other highly invasive species.

We evaluated the human health and ecological effects associated with herbicide use. We conclude that the impacts would be minimized by restriction to aminopyralid and glyphosate which are relatively low toxicity herbicides, and posting of signage in sprayed areas. These herbicides can facilitate control, in the appropriate situations, of the full suite of highly invasive plants yet also are regarded as minimally detrimental to human health, biological resources, and ecosystem services. Additionally we would institute practices to further ensure safe herbicide use including a minimum threshold size of infestation (more than 10 plants per infestation area), a prohibition on use of aminopyralid 10 feet from water bodies (USNPS 2008), and limits on maximum annual use of herbicide (e.g., 2.5 gallons of aminopyralid, and 32.5 gallons of glyphosate). Proposals for site-specific application of herbicide would require additional systematic review and approval by the agency to ensure that the proposed use was appropriate, site environmental characteristics were evaluated, and safety standards were met.

5.0 Consultation and Coordination

We announced our intention to develop this EA, described the anticipated proposed action, and solicited input of interested parties in a scoping letter issued in July 2009 (Appendix B). The letter was distributed to 174 parties (individuals, conservation organizations, municipalities, congressional representatives, lawsuit plaintiffs, local media, etc.). Six responses were received. Two responses supported an IPM approach including herbicide use. Four responses expressed concerns about potential human health and ecological impacts associated with proposed use of two herbicides. Refer the following chapters and sections for a summary of concerns: 1.4.1 through 1.4.4 and 2.5.

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Appendix A. Information on pesticide use proposals.

U.S. Fish & Wildlife Service

Pesticide Use Proposals

One Step Toward Protecting Trust Resources

What are Pesticide Use Proposals?

A Pesticide Use Proposal (PUP) is information required by the U.S. Fish and Wildlife Service (Service) before application of a pesticide on Service property. It is a protective measure to ensure the proper use of pesticides on Service lands. The form asks for a variety of information including where the pesticide will be applied, what pesticide will be used, what species will be managed with the pesticide, and whether or not there are any endangered species in the pesticide application area.

What are the relevant authorities for PUPs?

Many authorities relate to pesticides and PUPs. Some of them include the Federal Insecticide, Fungicide, Rodenticide Act; Endangered Species Act; National Environmental Policy Act; Department of Interior, Pesticide Use Policy (517 DM 1); Service Pest Management Policy and Responsibilities (30 AM 12); and National Wildlife Refuge System Pest Control Policy (7 RM 14).

Who approves PUPs?

PUPs are usually approved by the Service Environmental Contaminant or National Wildlife Refuge staff at the field, regional, and national levels, depending on the pesticide being proposed for use.

With Rachel Carson as part of our legacy, pesticide use proposals are one critical step we can take to ensure proper pesticide use on Service lands. Pesticides play a role in resource management, but they must be used with proper precautions.

What benefits do the Service gain from PUPs?

Pesticide Use Proposals help ensure:

- Pesticides are used safely
- Pesticides are used effectively
- The lowest risk products are selected
- Pesticide label instructions are followed
- The best products are selected for the target pests
- Adequate pesticide application buffers are maintained
- Protection of groundwater and surface water
- Compliance with the Endangered Species Act and other applicable laws and regulations
- Reductions or eliminations of unnecessary pesticide use.

In 1962 Rachel Carson wrote the bestselling book, Silent Spring, which warned about the dangers of pesticide use and misuse.

How many PUPs are submitted each year?

At the field and regional levels, over 1,000 PUPs are reviewed each year. In 2004, the Washington Office reviewed over 440 PUPs.

Why does the Service use pesticides?

The Service uses pesticides as one tool in an integrated pest management approach in managing pest species that interfere with resource management objectives. Most of the pesticides the Service uses are on National Wildlife Refuges for the management of non-native invasive species, such as Canada thistle (*Cirsium arvense*), johnson grass (*Sorghum halapense*), and phragmites (*Phragmites australis*). These species out compete the native species, which is detrimental for native ecosystems. Pesticides play a role in resource management, but they must be used wisely along with other measures to manage and/or eliminate pest species.

Pesticide use proposals help ensure pesticide affects to non-target organisms, like these wood ducks, are eliminated.

Contact Information:

U.S. Fish & Wildlife Service
1 800/344 WILD
http://www.fws.gov

Division of Environmental Quality
4401 N. Fairfax Drive, Room 322
Arlington, VA 22203
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February 2005

Appendix B. Scoping letter issued to public on 13 July 2009.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kodiak National Wildlife Refuge
1390 Buskin River Road
Kodiak, Alaska 99615
(907) 487-2600

13 July 2009

Kodiak National Wildlife Refuge is preparing an environmental assessment (EA) regarding management of invasive plants. An EA is a concise public document that provides sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact. The EA will describe the purpose and need for management, detail options (alternatives), evaluate the environmental consequences of undertaking those actions, and provide an opportunity for public involvement. The end result of the EA will be a decision on which management option best meets Refuge and program objectives for invasive plant management while minimizing environmental impact or a decision to prepare an environmental impact statement.

History of Invasive Plant Management at Kodiak National Wildlife Refuge
Invasive plants are non-native species considered to have high potential for displacing native plants, disrupting ecosystem function, and degrading fish and wildlife habitat. Invasive plants pose an increasing threat to the integrity and productivity of fish and wildlife habitats on National Wildlife Refuges. On Kodiak NWR, we are very concerned about invasive plants despite the limited number of species and limited abundance. Currently we know of four species that infest less than 50 acres of the 1.9-million acre Refuge.

To address this threat, the Refuge initiated a management program in 2003. To date, this program has consisted of the following primary elements:

- Public outreach to increase awareness of invasive plant threats and to prevent establishment of new invasive plant infestations on the Refuge, and in the Kodiak Archipelago;
- Field surveys to document the type, location, and extent of infestations and environmental characteristics of infestation sites;
- Evaluation and approval by the Service's Alaska Regional Office of Integrated Pest Management (IPM) Plans submitted by the Refuge pertaining to orange hawkweed (2003), oxeye daisy (2007), and Canada thistle (2007);
- Evaluation and approval by the Service's Alaska Regional Office of Pesticide Use Proposals (PUP) submitted by the Refuge, as required by Fish and Wildlife Service policy;
- Secure funding, establish cooperative partnerships, and implement tactical aspects of plans including education; outreach; surveys; management of identified invasive plant infestations; and follow-up monitoring of plant and habitat responses to management.

Results indicate that public awareness has increased, threat of establishment of new infestations has decreased, and infestations of orange hawkweed, Canada thistle, and oxeye daisy have been substantially reduced.

Proposed Action

The Refuge proposes to continue use of clopyralid-based herbicide to control orange hawkweed in the Camp Island vicinity of Karluk Lake and aminopyralid-based herbicide to control Canada thistle at Garden Island in Uganik Bay, and oxeye daisy at Refuge Headquarters as prescribed in IPM Plans. IPM is a systematic planning, evaluation, and decision-making process used to guide and direct management of pests such as invasive plant species. Specifically, the IPM approach requires evaluation of pest biology, infestation characteristics, environmental factors, and reported effectiveness and environmental impact of various methods of pest management including cultural (e.g., sanitation practices), biological (e.g., insect plant predators), manual (e.g., hand-pulling), mechanical (e.g., mowing), and chemical (e.g., herbicides). The outcome of this evaluation process is a decision on the method, or combination of methods, which will be applied to manage the pest species and infestations.

When an infestation of orange hawkweed, Canada thistle, or oxeye daisy is documented at a new location outside the scope identified in an existing IPM Plan, we would amend the IPM Plan to include management of that infestation. Clopyralid- or aminopyralid-based herbicide would be used to manage this infestation when an IPM evaluation indicated that its application could best achieve the elimination objective while minimizing economic, health, and environmental risks. The IPM approach also calls for follow-up monitoring to determine whether, in fact, such an objective was achieved. If not, then the current method would be stopped, re-evaluated, modified, or replaced. The EA will specifically evaluate use of the two aforementioned herbicide types and potentially establish criteria for maximum annual use of, or area treated with, herbicide.

A new IPM Plan would be developed when we encounter an infestation of other invasive species (e.g., bull thistle). The aforementioned approach would be applied, and herbicide use would be allowed, if this method was determined to best meet an infestation elimination objective, and the target invasive species was one that could be effectively managed with either of the herbicide types previously used by the Refuge and subject to evaluation in this EA.

A new EA would be developed when an IPM evaluation indicated that the management objective was best achieved with herbicide, but would require use of a different type of herbicide. Consistent with Service policy, herbicide use would occur only after a Refuge-submitted Pesticide Use Proposal was evaluated and approved by the Service's Alaska Regional Office.

As prescribed in approved cooperative agreements, IPM Plans, and Pesticide Use Proposals, herbicide use would be allowed to manage infestations of invasive plants on federal lands administered by Kodiak NWR, land of cooperating private landowners within the legislative boundaries of Kodiak NWR, Service-owned and leased land in Kodiak (e.g., Kodiak NWR Headquarters), and land administered by Alaska Maritime NWR adjacent to Kodiak Island. Outside of these areas, we would provide, as requested, technical assistance with management of invasive plants, consistent with Service policy and our commitment to facilitate private- and public-sector efforts in the Kodiak Archipelago Cooperative Weed Management Area. Technical assistance could include: advice on outreach and management options; demonstration of management methods; and participation in management actions planned by the landowner and approved by the appropriate permitting authorities.

The first stage of the environmental assessment process is to request public input on the scope of the EA. Please take a moment to consider the threat of invasive plants and how that threat should be best managed on Kodiak NWR and holdings of Alaska Maritime NWR adjacent to Kodiak Island. If you have specific comments regarding invasive plant management on Kodiak NWR, please include them in your response to this message. Your comments will be considered in the preparation of the EA. Comments may be submitted by August 14, 2009, to the Refuge Manager at the address above or emailed to the Refuge at Kodiak@fws.gov. For additional information on this project, please contact Bill Pyle, Supervisory Wildlife Biologist (Bill_Pyle@fws.gov; 907-487-0228). We anticipate completing the EA by November 2009 and having it available for a 30-day public review.

Sincerely,

W. H. Pyle

for Gary P. Wheeler
Refuge Manager

3

Appendix C. ANILCA 810 Evaluation

Kodiak National Wildlife Refuge
Evaluation of the Effects on Subsistence Uses and Needs
(ANILCA Section 810 Evaluation)

The U.S. Fish and Wildlife Service, acting for the Secretary, is required by Section 810 of the Alaska National Interest Lands Conservation Act (ANILCA) to evaluate the effects on subsistence uses and needs in determining whether to withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands on national wildlife refuges in Alaska. The evaluation of effects of this proposed action or use on subsistence uses and needs is documented below. If this evaluation concludes a finding that the proposed action would result in significant restriction to subsistence uses, and we wish to proceed, we must initiate further procedural requirements of Section 810.

Proposed Action/Use:

Kodiak National Wildlife Refuge (NWR) manages refuge lands for natural biodiversity as required by U.S. Fish and Wildlife Service policy and the establishing purposes of the refuge. Allowing invasive plant species to colonize and degrade native habitats on refuge lands is contrary to these legal mandates. In 2002, refuge staff discovered non-native, invasive plants on refuge lands. Since that time, the refuge has employed an Integrated Pest Management (IPM) approach to determine which method or combination of methods would be most appropriate to manage invasive plant species on refuge lands. The purpose of the proposed action is to protect the natural diversity of habitat on refuge lands by preventing establishment of new infestations of highly invasive plant species, and to restore natural diversity of habitat where it has been impacted by existing invasive plant infestations.

To accomplish the proposed action the refuge has used the IPM approach to evaluate multiple characteristics of invasive plants while also considering the efficacy of known eradication methods and potential environmental impacts. This rigorous evaluation process determined that the use of herbicides would be required for successful eradication of invasive plant species on refuge habitats. The proposed action would be followed by continued monitoring and preventions strategies to reduce the chance of re-infestation. A more thorough description of the project including maps of known invasive plant infestations can be found in the Environmental Assessment Integrated Pest Management of Invasive Plants on Kodiak National Wildlife Refuge and Vicinity.

Evaluation:

1. Subsistence Resources, Uses and Needs in the Affected Area:

Residents of Kodiak Island rely on and harvest an abundance and diversity of fish, game, invertebrates and plants for subsistence purposes. Most subsistence activities occur near communities, along the coast, and on the lower reaches of major rivers where lands are primarily in private ownership. Access to interior areas of the Refuge is often difficult and expensive when compared to access to coastal areas.

Almost three quarters of the total pounds of subsistence resources harvested are fish. Salmon is particularly important and makes up more than half of the total pounds harvested. Land mammals such as deer and elk are also important wild food resources, contributing an average of 40 pounds per person each year. Subsistence harvest seasons are in place for elk on Refuge lands on Afognak Island, but no elk have been harvested to date. A federal subsistence hunt initiated in 1997 for residents of Kodiak Island villages to harvest brown bears has averaged a take of two bears per year.

Other important resources include shellfish such as crabs and marine mammals such as harbor seals and northern sea otters.

2. Effect of Proposed Action or Use on Subsistence Uses and Needs.

The proposed action should have no effect on subsistence uses or needs. Most subsistence activities in the Kodiak Archipelago occur near communities, along the coast and on lower reaches of major rivers where lands are primarily in private ownership. In some areas of the refuge subsistence could overlap the lowland area where most invasive plants occur. However, the areas where invasive plant management was conducted by the Refuge between 2003 and 2008 are not known to have been used for subsistence purposes. The small size of the areas infested with invasive plants, limited subsistence resources and high cost of access make these areas less desirable for subsistence use than many other areas of the Refuge.

3. Availability of other lands for the purpose sought to be achieved.

The goal of the proposed action is to protect the natural diversity of habitat on refuge lands by preventing establishment of new infestations of highly invasive plant species, and to restore natural diversity of habitat where it has been impacted by existing invasive plant infestations. Therefore, no other lands can be used to achieve that purpose.

4. Alternatives which would reduce or eliminate the proposed action from lands needed for subsistence purposes.

There is no other way to conduct the proposed action on lands other than where the non-native plant infestation has occurred. If successful, the project would restore natural habitat that supports subsistence resources.

Finding:

Based on review and evaluation of information indicated above and in the supporting references indicated below, I have determined that the proposed action will not result in a significant restriction of subsistence uses. If successful, the proposed action has the potential to restore native plant communities that benefit subsistence resources.

Agency Decision:

A finding of no significant restriction in subsistence uses completes the Section 810 requirements. The proposed action or use may be authorized.

Supporting References:

Alaska Policy Manual, U.S. Fish and Wildlife Service

Alaska National Interest Lands Conservation Act (ANILCA), 1980.

Fall, J. A., ed. 1991. "Subsistence harvest and uses in seven Gulf of Alaska communities in the second year following the Exxon Valdez oil spill." Alaska Department of Fish & Game, Division of Subsistence Technical Paper 218, Juneau, Alaska. 300 pp.

Fall, J. A., and C. Utermohle. 1999. “Subsistence harvest and uses in eight communities ten years after the Exxon Valdez oil spill.” Alaska Department of Fish & Game, Division of Subsistence Technical Paper No. 252. Juneau, Alaska. 646 pp.

Scott, C., A. Paige, and L. Brown. 2001. Community profile database. Alaska Dept. Fish & Game, Division of Subsistence, Anchorage, Alaska.

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Subsistence Management for Federal Public Lands in Alaska, Final. 1992.

USFWS. 2008. Revised comprehensive conservation plan [for] Kodiak National Wildlife Refuge. U.S. Fish and Wildlife Service, Anchorage, AK.