National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Invasive Plant Management for Kenai Fjords National Park

2012 Summary Report

Natural Resource Data Series NPS/KEFJ/NRDS—2013/430

ON THE COVER

Clockwise from top left: Kenai Fjords National Park Biological Technician surveying the Edge of the Glacier Trail for invasive plants; June dandelions (*Taraxacum officinale*) growing on the outwash plain; 2012 Alaska EPMT controlling bird cherry *(Prunus padus*) in the Anchorage area.

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Abbreviations

AACD	Alaska Association of Conservation Districts
AKNHP	Alaska's Natural Heritage Program
EPMT	Exotic Plant Management Team
GIS	Geographic Information System
GPS	Global Positioning System
HIT	Harding Icefield Trail
KEFJ	Kenai Fjords National Park
MV	Marine Vessel
NPS	National Park Service
PUC	Public Use Cabin
RBCA	Resurrection Bay Conservation Alliance
SAGA	Southeast Alaska Guidance Association
SCA	Student Conservation Association
USFS	United States Forest Service
YCC	Youth Conservation Corps

Abstract

This report describes the work performed by the Exotic Plant Management Team at Kenai Fjords National Park for the 2012 field season. 2012 marks the ninth consecutive year that Kenai Fjords National Park has monitored and controlled invasive plants following the management protocol established by the Alaska Exotic Plant Management Team. The 2012 Kenai Fjords Exotic Plant Management Team, coordinated by the park's Environmental Protection Specialist, included one Biological Science Technician, one Student Conservation Association intern, and two Youth Conservation Corps crew members. Volunteers, community groups, and partner organizations assisted the Kenai Fjords crew with invasive plant control efforts. As with previous seasons, monitoring and control work focused on the Exit Glacier area and along the Exit Glacier Road. Other areas within the park that were controlled in 2012 included sites on the outer coast in Nuka Bay, McCarty Fjord, and Aialik Bay. Control work was mostly performed manually, though herbicide control was conducted on backcountry populations of common dandelion (*Taraxacum officinale spp. officinale*) in the Exit Glacier area. All invasive plant infestations were mapped using two Trimble GeoXT global positioning system units. Data was post-processed and edited using GPS Pathfinder Office software. The Kenai Fjords Exotic Plant Management Team surveyed 21.4 acres of park lands and 5.5 acres outside park boundaries for invasive species. A total of 8.9 acres of invasive plant infestations were mapped. The team treated 7.3 acres of invasive plant infestations, 4.8 of these acres were controlled with herbicide. 488 pounds of invasive plants were manually pulled and removed from the park. This season a number of small, but previously unknown infestations of invasive plants were discovered in the Exit Glacier area, as well as one remote infestation of common dandelions found at Beauty Bay. Monitoring and control efforts should continue in Kenai Fjords National Park to prevent the further spread or introduction of invasive plants within the park and to keep native ecosystems intact. 2012 marks the second consecutive season that Alaska Exotic Plant Management Team staff conducted monitoring for invasive European and Asian Gypsy Moths (*Lymantria dispar* and *L. dispar japonica*). Traps were set at Exit Glacier due to the sites vulnerability to invasive introductions. After repeated checks throughout the season the traps were found to be free of Gypsy Moths. Monitoring for these species should continue as they pose a significant threat to the native vegetation of the area.

Acknowledgments

The 2012 Kenai Fjords Exotic Plant Management Team would like to thank all the volunteers, community groups, park employees, and visitors who helped to make the 2012 field season a success. A special thanks to the Kenai Fjords Exotic Plant Management Team members: Student Conservation Association interns, Stacey Torigoe and Eric Moll; Christian Tofson and Brandon Moore of the Youth Conservation Corps; Environmental Protection Specialist, Christina Kriedeman, and to Tim Federal who provided invaluable field support and served as liaison for the regional Alaska Exotic Plant Management Team. We would also like to thank the Southeast Alaska Guidance Association crews, the Chugach National Forest's Student Conservation Association crew, the Resurrection Bay Conservation Alliance, Alaska Association of Conservation Districts Invasive Plant Coordinator (Jen Kain), and all Kenai Fjords employees that helped during the Community Weed Pull event.

Introduction

Kenai Fjords National Park (KEFJ), at over 1500 square miles, is dominated by the massive Harding Icefield and the many glaciers flowing off of it. Over 500 square miles of park land is covered in glacier, and much of the rest of the park can be classified as early-succession, post-glacial environment. These recently disturbed landscapes are highly susceptible to invasion by a number of non-native, invasive plant species which can out-compete native species and have a negative impact on natural ecosystem diversity and processes.

With landscapes so young and relatively pristine, KEFJ is in a unique position to be able to effectively control the intrusion of invasive plant species before they become established on park lands and to avoid the difficulties that riddle compromised ecosystems in many other parts of the United States and the world. The National Park Service (NPS) Exotic Plant Management Team (EPMT) program offers a systematic approach to invasive plant management, focused on the principles of 1) prevention, 2) inventory and monitoring, 3) treatment and control, 4) early detection and rapid response, and 5) restoration. By preventing the spread of invasive seed and propagules into the park, catching invasions before they become established, and dealing with them in early stages of population growth, KEFJ can maintain ecological integrity and allow plant succession to proceed unimpaired.

Much of the land in KEFJ that is not buried beneath the Harding Icefield is a fjordland located on the southern coast of Alaska's Kenai Peninsula that opens into the Gulf of Alaska. Most people that visit these coastal fjords do so in tour boats and never step foot onto land. The vector to introduce invasive seeds into this area is, therefore, very small. The Exit Glacier area in the northeast corner of the park, on the other hand, is easily accessible by road and has the most visitor use. According to KEFJ traffic counters, 111,167 people visited the Exit Glacier area between May 26 and August 31 of 2012. The eight mile road accessing the park crosses private, State of Alaska, and US Forest Service (USFS) managed lands before it enters KEFJ. This road is infested with several invasive plant species and provides a ready vector for their introduction into the Exit Glacier area of the park.

The Kenai Fjords EPMT implements a strategy where park lands in the Exit Glacier area are regularly monitored and systematically controlled for invasive species. Remote infestations further up the trail system and at rarely visited sites in outer coast fjords, receive swift control efforts in order to keep these plants from becoming established in undisturbed, and hard to reach areas. The Exit Glacier road, with its easy accessibility, high visitation level, and well-established infestations of common invasive species requires intensive treatment, beyond the time and resource constraints of the park EPMT to control these populations. Treating well established front-country populations is, therefore, a lower priority than backcountry infestations that tend to cover smaller areas, and are located in less developed, harder to reach, areas. By continually pushing invasive species towards the front-country it is hoped that exotic plant invasion can be kept from spreading to other areas of the park.

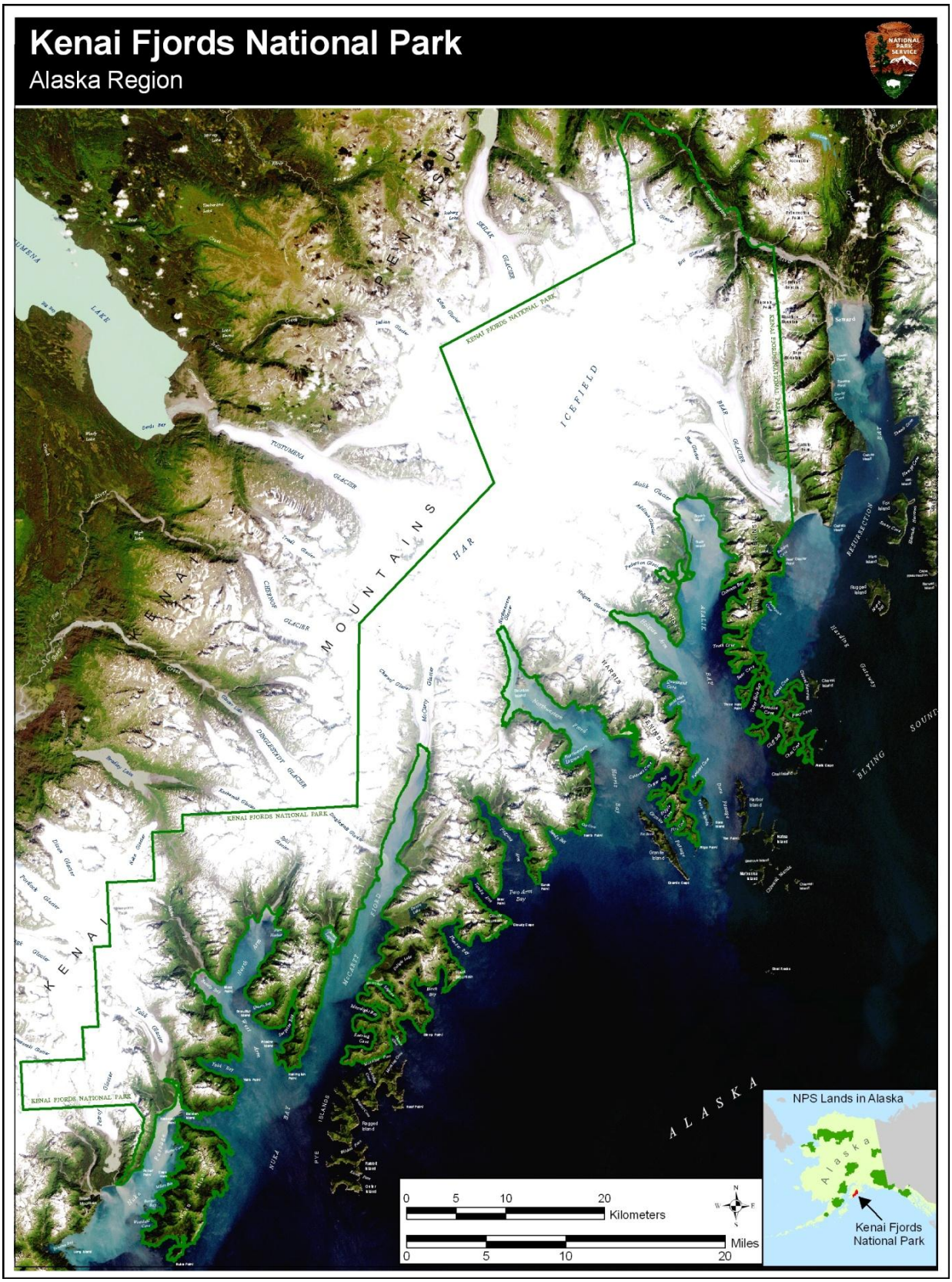

Figure 1. Location map of Kenai Fjords National Park (Kurtz 2010).

Methods

The EPMT protocol has been utilized in KEFJ since 2003. The park EPMT applies the invasive plant management strategy described in the Alaska Exotic Plant Management Team 2012 Field Protocol (Million, et al., 2012). The ultimate goal of this approach is to prevent the introduction of invasive plants, to inventory and monitor exotic populations that already exist, and to work towards control and eventual eradication of established populations of non-native, invasive plants in the park.

Figure 2. EPMT Technician mapping common dandelions (*Taraxacum officinale*) with a Trimble GPS unit.

Surveying and mapping is done with a Trimble GeoExplorer 2008 series GeoXT global positioning system (GPS). Historical data, collected by park staff in previous years, is loaded onto the units and assists field teams in returning to surveyed populations for treatment. All infestations are mapped, and historical infestations are revisited and inventoried for the presence of exotic plants. Additionally, each year new sites are selected to survey due to their proximity to existing invasive plant populations or their susceptibility to infestation, and are mapped and inventoried. Field collected data is post processed and edited by KEFJ staff using GPS Pathfinder Office software. Edited and reviewed data is then uploaded to the Alaska Regional EPMT office where the information can be compiled.

Figure 3. SAGA service crew and KEFJ EPMT after invasive plant control operations.

The 2012 field season lasted from June 4 through August 29 with a number of core staff serving shorter seasons within that timeframe. Work was led and organized by a Biological Science Technician and was assisted by a Student Conservation Association (SCA) intern, two Youth Conservation Corps (YCC) interns, as well as one volunteer group from Southeast Alaska Guidance Association (SAGA). Park and Alaska regional EPMT staff co-conducted the herbicide application operations within the park. A number of other KEFJ staff members helped during a volunteer event and as needed based on availability and experiential knowledge.

Distribution of Invasive Plants

Invasive plant populations in KEFJ are concentrated in the areas of highest use, with the Exit Glacier area containing the greatest number and diversity of invasive plant infestations in the park. 2012 efforts were focused on removal and containment of Exit Glacier invasive plant populations and on the complete removal of smaller infestations found elsewhere in the park. Monitoring and inventory sites in 2012 were associated with previously known infestations in the Exit Glacier area, and on sites along the outer coast most likely to have seen visitor use. Invasive plant infestations are controlled based on the likelihood that the population can be effectively controlled with available crew resources, and on the probability of the infestation expanding into other non-impacted areas. The EPMT generally gives the most exhaustive treatment to small and isolated infestations before they can spread and grow, and to sporadically occurring individual plants before they can set seed and establish new infestations.

Exit Glacier Road

The Exit Glacier road is infested with significant populations of a number of non-native plant species, and provides a ready vector for introduction of these plants into the park. The first seven miles of the road pass through a variety of land jurisdictions including private property, State of Alaska, and USFS lands and contain a number of extensive infestations of invasive plants. The final 1.5 miles of Exit Glacier road are located within the KEFJ park boundary, terminate at the Exit Glacier parking lot, and show the largest and densest dandelion infestations within the park as well as smaller infestations of several other species. The 1.5 miles of park road are mapped for all invasive plant species, with most species receiving swift and thorough manual control. Dandelion control, on the other hand, is severely limited by the extents of the infestation and the small crews that are allocated to EPMT work. Control along the road focuses on areas where people get out of their cars and access park facilities, trails, and backcountry areas. It is hoped that by keeping these areas relatively invasive plant free, that new seed introductions can be dealt with swiftly and effectively, and that seed spread into more pristine areas of the park can be diminished.

Exit Glacier Parking Lot

The Exit Glacier parking lot receives intensive treatment for several invasive plant species. Control work begins early in the season, as soon as plants begin to emerge in the spring, and is repeated periodically throughout the season. Retreatment is necessary in order to map and control any plants that emerge later, or were missed in previous sweeps, before they can go to seed. The parking lot contains a number of species, but annual efforts have kept population sizes down to manageable extents for manual control by the EPMT. In 2012 common dandelion (*Taraxacum officinale*) and white clover (*Trifolium repens*) were the first invasive plants to

emerge in June, followed in July by plantain (*Plantago major*), sheep sorrel (*Rumex acetosella*), pineapple weed (*Matricaria discoidea*), and common Timothy (*Phleum pretense*). Species common to the road outside the park run a high risk of germinating here through seeds and propagules introduced by park visitors. Species found here in isolated incidents prior to 2012 include oxeye daisy, Kentucky bluegrass, and red clover. All of these species have been controlled and have not returned to the roadside in recent years.

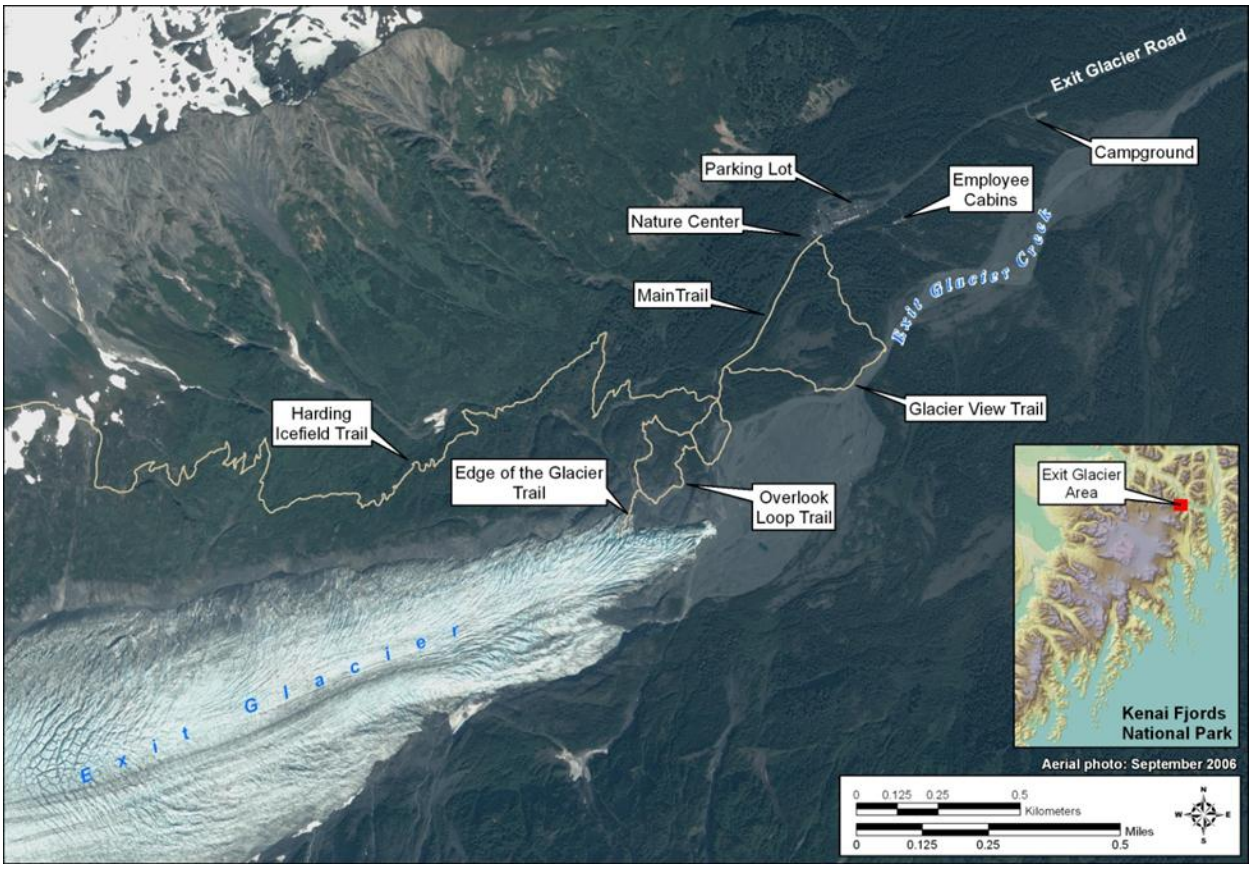

Figure 4. Developed sites in the Exit Glacier area (Kurtz 2010).

Employee Housing

The park maintains three cabins in the Exit Glacier area as seasonal staff housing. This area also contains a trail crew tool shed, a seasonal camping area for visiting field crews, and a common parking area. As with the Exit Glacier parking lot, this area runs a high risk of infestation from vehicles, tools, and personal gear brought into the park from other areas. Invasive plant infestations here have so far been of very small extents and easy to manually control. Species mapped and controlled here in 2012 include dandelion, annual bluegrass, plantain, and pineapple weed. Two sweeps were conducted in 2012, one in mid-July and a follow-up in late August.

Campground

A free public campground, off Exit Glacier road one half mile east of the Exit Glacier parking lot, sees many visitors in the summer season. The area contains 13 walk-in campsites and a common cooking shelter and fire-pit, vault toilets, and parking area. Small numbers of dandelion, plantain, and pineapple weed are found along the access road and around the parking area, and more extensive patches of annual bluegrass grow in the gravel of the parking lot. Control here is swift and thorough to keep plants out of the campsites which have remained significantly free of invasive plants (there was one dandelion plant controlled within the campsites in 2012).

Figure 5. Manual control of annual bluegrass (*Poa annua*).

Exit Glacier Trails

A large portion of control work is devoted to the trail system, which comprises the lower trails including the Glacier View, Overlook Loop, Edge of the Glacier, and main trail, and the 4.1 mile Harding Icefield Trail. Invasive species found on these trails include dandelions, plantain, pineapple weed, annual bluegrass, and mouse-ear chickweed. All species' infestations, with the possible exception of annual bluegrass, are small and easily controlled. All trails are surveyed and mapped. When individual plants and small infestations are encountered they are mapped and manually controlled. Larger infestations, such as annual bluegrass along the Harding Icefield Trail and the main trail, are mapped ahead of time and controlled later with additional assistance from visiting SAGA service crews. By controlling these extensive infestations with the help of additional manpower it is expected that the remaining annual bluegrass infestations will be patchy and easy for EPMT staff adequately finish control within a few years.

Occasionally time and resource constraints force EPMT to selectively control infestations, therefore a priority strategy has been developed. All trails are a high priority for control efforts because they are a vector for the spread of invasive plants into undeveloped areas, but backcountry infestations such as those along the Harding Icefield Trail, and infestations with the highest risk of spreading into uninfested areas such as the Overlook, and Edge of Glacier Trails, receive the highest treatment priority. In 2012, the EPMT controlled all invasive plants encountered along the trails with the exception of small patches of annual bluegrass along the main trail due to time and staffing constraints.

Outwash Plain and Nike Stripe

With the exception of Exit Glacier Road, the outwash plain contains the largest infestation of dandelions found in KEFJ. The outwash plain, south of Exit Glacier Road and across Exit Creek, as well as the Nike Stripe, north of the road, are remote infestations in otherwise unimpacted areas, and are a very high priority for treatment. Prior to 2011, all invasive plant removal efforts involved manual control (hand-pulling with the use of shovels and root-digging tools). 2011 marked the first year that chemical control was conducted on these infestations. All spray operations in KEFJ are conducted by crew members that have received training and earned certifications as State of Alaska licensed Pesticide Applicators. The herbicide Milestone, with the active ingredient aminopyralid, is applied at a rate of 4 ounces of herbicide concentrate per acre. Prior to application herbicide is mixed with water at 0.1 ounces of Milestone per gallon of water. The prepared mixture is then applied to dandelions using backpack sprayers and spot-spray application methods. In this way herbicide use is focused directly onto target plants and overspray into the surrounding area is minimized. Chemical control methods allow treatment of extensive areas using minimal staff labor and park resources, and it is anticipated, will result in fewer negative impacts on the environment than if manually controlled with larger crews. Effectiveness of chemical methods will continue to be monitored over time.

Figure 6. KEFJ Biological Technician applying herbicide on the outwash plain.

Maintenance Yard

The KEFJ maintenance facility is located outside the park boundary in a neighborhood area just off the eastern end of Exit Glacier Road. This is where many park vehicles are stored, and where maintenance staff conducts a great deal of their project work, which is eventually installed within park boundaries. This area is close to the town of Seward, in a densely inhabited residential area with a history of intensive use, and as a consequence, there are significant populations of a several invasive species. Because park vehicles and maintenance equipment regularly work within park boundaries, it is extremely important the maintenance site is free of invasive plant seed and propagules that could potentially be introduced by staff into park grounds. EPMT staff returned to the maintenance yard on three occasions in 2012, first controlling emergent dandelions and plantain, with returns to check the area for pineapple weed, annual bluegrass, mouse-ear chickweed, and common chickweed.

Outer Coast

There was one EPMT trip to the outer fjords of KEFJ in 2012 aboard the park vessel, the M/V Serac. Four EPMT members participated in the four-day trip in mid-July. The trip began at the park's western extent, at the Beauty Bay airstrip where common Timothy has been controlled annually since 2006 (Weatherbee 2006). After extensive searching, Common Timothy was not found at this site, but a previously unknown infestation of dandelions was discovered and manually controlled on the southern end of the airstrip. The trip's next stop was in McCarty

Fjord, at the dandelion infestation on the cliffs just south of the Dinglestadt glacier. Seven hours was required for a crew of four to revisit and control all previously known infestations. New infestations were found in 2012 in brushy areas beneath cliffs already known to have dandelions with many found growing on steep and slick terrain. One new population was found on the face of a 30-foot, nearly vertical cliff, which is inaccessible without proper climbing gear and technical training, and was therefore not controlled in 2012.

The final three sites visited are located in the park's easternmost fjord, Aialik Bay. Both the Holgate and the Aialik Public Use Cabins are infested with annual bluegrass on access trails and in the gravel around the cabins. Aialik PUC also contains a dense infestation with 85 stems of curly dock (*Rumex crispus*) located where the cabin access trail meets the beach. All plants were mapped and controlled. In 2011 a September return trip to the PUCs in Aialik Bay was effective in controlling late season regrowth of annual bluegrass, but time and resource limitations did not allow a late season retreatment in 2012. The final outer coast infestation, in Aialik Bay on Port Graham Native Corporation land, was first discovered in 2011 at the staging and launching area, and kayak storage site for Kenai Fjords Glacier Lodge on the north side of the outer beach at Pedersen Lagoon. In 2012, the EPMT and Kenai Fjords Glacier Lodge staff worked together and controlled annual bluegrass, common plantain, and pineapple weed. This area should remain a high-priority as visitors kayaking and hiking to other beaches and backcountry sites might carry plant propagules to currently uninfested areas. Before entering this site KEFJ staff must contact lodge staff via email or satellite phone to inform them of our work intentions and to arrange proper timing for our visit. Cooperation with lodge staff is essential for continued access to this site and as an opportunity to educate lodge staff about the problem of invasive plants.

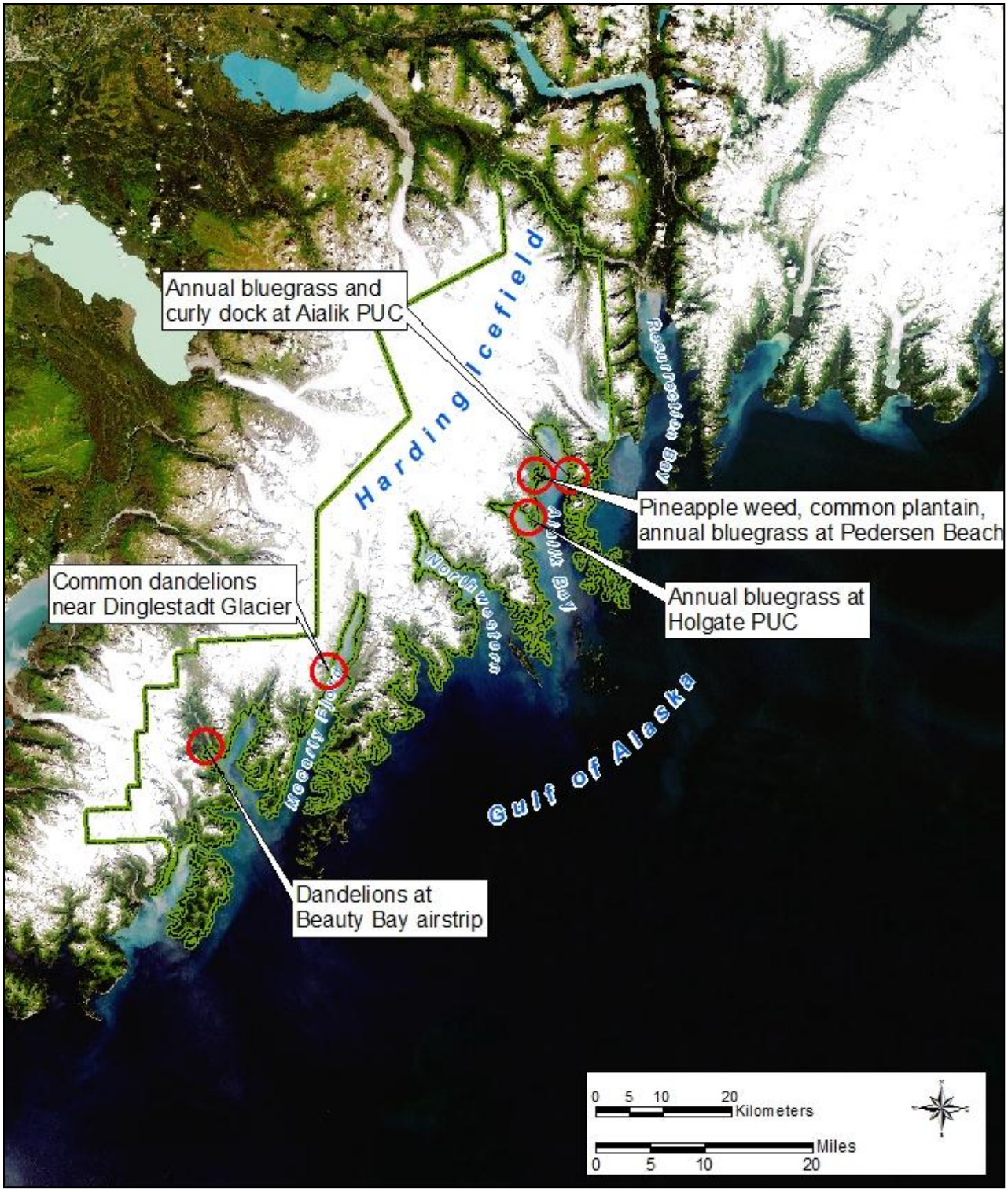

Figure 7. Sites of known invasive plant infestation on the KEFJ outer coast controlled by the EPMT in 2012.

Results

Overview

EPMT efforts at KEFJ in 2012 were focused on revisiting all previously mapped non-native plant populations and on thorough control of as many of these infestations as possible. New infestations of invasive plants, all associated with previously known populations, were found, mapped, and treated in the Exit Glacier area in the parking lot and at the outwash plain, and on the outer KEFJ coast at Beauty Bay and at Dinglestadt Glacier. Total species acres surveyed, species acres infested, and acres treated by EPMT decreased slightly in 2012 compared to 2011 (Table 1). Most of this decrease is attributable to the lack of extensive manual control efforts along Exit Glacier Road in 2012. In June 2011, which had a light snow pack and early plant phenology, a visiting SAGA service crew assisted the EPMT in the control of dandelions in a number of areas along the park road. There was no comparable effort in 2012 due to a lingering snowpack, a late phenology, and the lack of an early season service crew. In 2012, a concerted effort was put forth to increase the area of dandelions controlled chemically from 3.1 acres in 2011 to 4.8 acres in 2012. To facilitate this goal, two members of KEFJ attended courses and tested to receive Alaska State Pesticide Applicator's licenses. With the experience of 2011 spray operations, and more certified applicators on hand, two KEFJ staff and one regional EPMT member, total chemically controlled acreage increased significantly in 2012.

Invasive plant control efforts at KEFJ have been extremely effective in keeping non-native plant infestations and negative impacts on the native ecosystem to a minimum. These are, however, annual efforts that must continue each and every year in order to maintain the positive effects that have been gained over nine years of EPMT work in the park.

Table 1. Summary of Kenai Fjords National Park Exotic Plant Management.

Year	**Invasive GPS Data** NPS Lands (non-NPS lands)		
	Species Acres Surveyed	Species Acres Infested*	Acres Treated
2004	2.8 (0.5)	1.7 (0.5)	0.5 (0.5)
2005	9.7 (0.1)	2.8 (0.01)	2.3 (0.01)
2006	42.7 (0.3)	5.4 (0.3)	4.8 (0.2)
2007	23.5 (1.8)	5.2 (0.01)	1.9 (0.01)
2008	24.0 (0.2)	3.4 (0)	1.7 (0)
2009	26.1 (3.2)	2.7 (0.01)	2.3 (0.01)
2010	55.9 (5.9)	5.5 (0.01)	3.4 (0.01)
2011	27.6 (9.3)	7.5 (0.8)	6.1 (0.8)
2012	21.4 (5.5)	7.1 (0.2)	5.5 (0.2)

* Acres infested are calculated by acres mapped times the percent cover in areas greater than 0.5 acres. If under 0.5 acres, acreage mapped is counted as 100%.

Common Dandelion (*Taraxacum officinale ssp. officinale*) – Alaska's Natural Heritage Program's (AKNHP) Invasiveness Ranking 58

Common dandelion has the largest extents of any invasive plant species present within KEFJ. The areas of greatest infestation are along human-use corridors which have many historically established infestations, as well as an ongoing source of seed introduction through unintentional transport on visitor vehicles, clothing, and gear. Because of the large size of front-country dandelion infestations, and the limited crew resources that the park has to control them, KEFJ EPMT prioritizes control efforts to maximize effectiveness and thoroughness of treatment, with backcountry infestations being of the highest priority. Dense and extensive infestations along Exit Glacier road did not receive concerted treatment efforts due to the limitations of EPMT staffing size to significantly impact such an extensive infestation.

Exit Glacier Road

The westernmost 1.5 miles of Exit Glacier Road is within park boundaries and receives treatment from EPMT staff. Vehicles coming into the National Park have great potential to move seeds into and within the park through direct seed transport on vehicles, passengers, and their personal equipment, as well as indirectly by creating the necessary wind currents for the seeds to be blown along the roadside. Invasive plant control along Exit Glacier Road within the park is primarily an early season (pre-seed) effort focused on pushing dandelions back from the road's furthest extents (including the parking lot, campground, and commonly used roadside pullouts). In 2012, due to a late emergence of dandelion and quick phenological development with seed dispersal rapidly thereafter, control along the roadside was limited to early season deadheading (removing flowering parts from young plants to prevent them from setting seed). Deadheading was only conducted at the eastern extent of the park's section of road, directly on the west side of Resurrection River Bridge, while other areas were still covered in snow. By late-June, however, the roadside was awash in flowering dandelions, and at the same time higher priority trail and backcountry infestations were developing quickly. Control attention was then diverted to higher priority, more manageable off-road infestations.

Figure 8. Invasive plant control operations along Exit Glacier road.

Exit Glacier Parking Lot, Nature Center, and Employee Housing Facilities

Complete control of dandelions in and around the Exit Glacier area parking lots is, and should remain, a high priority for the EPMT due to the likelihood that dandelion seeds from these areas would be readily dispersed onto the trail system and other more pristine areas by park visitors. To achieve the goal of controlling 96 to 100 percent of all dandelions in the parking lots, and around park facilities such as employee housing, public restrooms, and the Nature Center,

exhaustive manual control efforts are conducted three or more time throughout the season (with most of these efforts occurring from early June through mid-July). These strategies have proven effective, even with a small crew, at keeping dandelion numbers very low in these areas. Dandelions, though common in the parking lot and around the Nature Center, consist primarily of widely dispersed individuals, which are easy to map and control and to keep from developing into more extensive infestations. One persistent dandelion infestation of 20 to 50 stems has been returned to year after year behind (just east) of Cottonwood cabin. In 2012 a survey was conducted down the Exit Glacier SNOTEL weather station access trail and in the clearing around the weather station. One very dense infestation was discovered in the northeast corner of the clearing. Though only one meter in diameter, this infestation had over 100 stems, and included very large individuals. This site should continue to receive treatment one or more times per growing season.

Exit Glacier Trails

The Exit Glacier trail system, from the paved Main Trail and heavily used lower trails, to the strenuous and therefore much less used Harding Icefield Trail (HIT), is a very high priority for treatment due to their proximity to pristine environments and the limited extents of infestations. Dandelion infestations along the trails come in two distinct forms: sporadic individual plants that were most likely introduced as isolated seeds carried in on hiker clothing or equipment, and dense, historically known populations that persist either vegetatively (from root-fragment regrowth), or through reseeding by plants unintentionally overlooked by EPMT. In 2012 all previously mapped infestations were returned to and manually controlled for 96 to 100 percent effectiveness. Sporadically occurring individuals are mapped and controlled manually on a regular basis as encountered throughout the season. Most trailside dandelions are found on the Main Trail, near the moraine at the start of the Glacier View trail, and on the lowest 0.8 miles of the HIT. One significantly larger infestation, with almost 200 stems controlled in 2012, is located just off-trail of a switchback on the northern portion of the Edge of Glacier trail loop. In 2012 this infestation was controlled after plants had already gone to seed. To prevent this from occurring in the future, park staff will need to make this site a priority and visit this site based on previous year's phenology record to reduce the chance of seeds dispersing before plants can be controlled. Because of this site's hidden aspect in trailside alder bushes and dense grasses, it should be revisited based on previous years' GPS map locations. Another isolated and persistent population is located near the bottom of an old section of the Harding Icefield trail closed after

Figure 9. EPMT crew members cross Exit Creek on the outwash plain to conduct herbicide application operations.

2008. This population has been manually controlled every year by the park EPMT since the trail was rerouted in 2010 and has continued to show a marked reduction in size and density.

Outwash Plain and the Nike Stripe

Across Exit Creek to the south of Exit Glacier Road is a large infestation of dandelions in the Exit Glacier outwash plain. This infestation was first documented in 2002 (Bryden 2002), and attempts to fully map the extents and to begin control efforts of this infestation first occurred in 2006 (Weatherbee, 2006). Monitoring and some control efforts have continued annually since 2007 with more exhaustive attempts in 2010 to map the full extents of this large and expansive infestation (Kurtz, 2010). The site was chosen to begin receiving chemical control in 2011 due to its difficulty of access, its location in an undeveloped area of the park, and the inability of EPMT to control the population using manual control. In 2011, the EPMT conducted its first ever herbicide application, and sprayed a total of 3.1 acres of dandelion infested land. This represented much more area than had ever received manual control in the past, yet it was a small portion of the total dandelion infestation on the outwash plain. In 2012, with more certified EPMT herbicide applicators on staff and a larger support staff to carry gear and help locate plants, the total area sprayed was increased to 4.8 acres at a rate of 4 ounces per acre (of herbicide concentrate). The treated area represents most of the known infestation on the outwash plain, with the westernmost outliers not controlled again in 2012 due to environmental constraints such as rainy weather and creek depth. The outwash plain infestation should continue to receive chemical control and monitoring of effectiveness for years to come.

Figure 10. Dandelion plant showing stress after herbicide application.

In addition to the herbicide treatments completed on the outwash plain, 2012 marks the first year that KEFJ EMPT chemically controlled the dandelion infestation on a remote area north of Exit Glacier road known as the Nike Stripe. Manual control has been an ongoing priority for the EPMT at this site since 2004 because of the small size and remoteness of this dandelion population (Bauder and Heys, 2005). Manual control over time has been effective in reducing overall infestation size and density. This infestation, though currently not as dense or as extensive as that found on the outwash plain, is a good target for chemical control due to its long-time persistence and its difficulty of access. It is anticipated that through chemical control this infestation can be fully eradicated from the park.

Maintenance Yard

In 2012 dandelion control efforts here began in early July. Most plants were still in a very early phenology (rosettes without flowers) and received very swift and effective manual control.

Outer Coast

The outer coast of KEFJ is currently known to have only two infestations of common dandelion on park lands. One newly discovered in 2012 and manually controlled by EPMT staff is at the southern end of the historic airstrip at Beauty Bay. This small infestation (an infestation point of sub-meter diameter) was discovered while attempting to relocate a known population of Timothy grass (*Phleum pretense*). This area should continue to be thoroughly monitored in future years to determine if the infestation is small and isolated, or if it's part of a more extensive population. The other dandelion infestation on the outer coast is associated with a number of rocky outcroppings to the south of Dinglestadt Glacier. This infestation was discovered in 2006, and has been controlled annually since then (Kurtz, 2010). In 2011 an effort was made to determine if the infestation stretched beyond the previously mapped extents. Similar rocky clearings to the south of the historic site were discovered to contain dandelions as well. A number of new patches of dandelions associated with already known infestations were discovered and controlled in 2012 (with the exception of one particularly hard to reach infestation found growing on the face of a 50-plus foot vertical cliff). The Dinglestadt infestation should continue to receive a great deal of effort due to its density, extents, and pervasiveness in an otherwise very pristine area. The EPMT recommends this site for consideration as a candidate for herbicide treatment in the future.

Annual Bluegrass (*Poa annua*) – AKNHP Invasiveness Ranking 46

Annual bluegrass, first documented in KEFJ in 2004 (Carlson et al., 2004), has been steadily increasing its extents and density along many human-use corridors within the park. 2010 marked the first year that the EPMT began manual control efforts on bluegrass along the Exit Glacier trails, with particular effort focused on an infestation observed to be steadily increasing up the Harding Icefield Trail (HIT) (Kurtz, 2010).

Exit Glacier Trails

In 2012, the EPMT once again put forth a concerted effort to fully remove annual bluegrass from the Exit Glacier trail system. The HIT, because it is less impacted, less traveled, and traverses more miles of pristine native ecosystems than the lower Exit Glacier Trails, is the highest priority for treatment of annual bluegrass. With the help of a six person SAGA service crew in early August, the EPMT manually controlled 96 to 100 percent of plants where they were mapped along the trail, from Marmot Meadows (1.6 miles) down. Late August and September hikes up the trail by the EPMT revealed extensive resprouting of annual bluegrass in many areas, but late season constraints in personnel and additional crew duties rendered retreatment impossible in 2012. Additional control efforts, with the help of SAGA, were

Figure 11. Hand-pulling annual bluegrass seedlings along the Main Trail.

conducted along the Main Trail and around the Nature Center facilities. Smaller, outlying infestations on the Overview Loop Trail were of limited extent and were readily controlled by core EPMT members. The Edge of the Glacier Trail, Overview Loop, and HIT should remain the highest treatment priorities for bluegrass within the park to keep it from spreading further into pristine and early succession habitats.

Exit Glacier Parking Lot

The main parking area at Exit Glacier contains dense infestations of annual bluegrass in many areas near parked cars and along the approach trails to the Nature Center. These infestations have not yet received control by the EPMT due to time and resource constraints. Until higher priority infestations are significantly reduced, infestations around the parking lot and approaching the Nature Center will be a low priority for control.

Exit Glacier Campground and Employee Housing

The parking lots for both the campground and the housing area have relatively low-density and small extent infestations within the gravel substrates. Complete manual control of these populations was conducted in 2012 to keep plants from spreading into the camping and living areas near-by. Sporadic bluegrass plants were found and controlled near Alder and Willow cabins, but none was found in and around the campsites or the cooking shelter.

Maintenance Yard

Annual bluegrass is found in significant but manageable numbers primarily on the north and east sides of maintenance's main building, and in areas along the northern fence line. These infestations were easily controlled in just a few hours by a four person EPMT crew. The manageable size, as well as the risk of its further spread, makes this infestation a very high priority for KEFJ EPMT.

Outer Coast

Three high priority infestations are found along the KEFJ outer coast, and all are within Aialik Bay. Holgate and Aialik PUCs have bluegrass growing in the access trails and around the cabins, but both are still of easily managed extents. The third bluegrass infestation, at the Kenai Fjords Glacier Lodge staging area on Pedersen Beach is sporadic and intermingled with pineapple weed along the lodge's access road. A four person crew, working a total of five hours removed 10 pounds of plants from these three Aialik Bay sites in July. An end of season return trip, to remove any bluegrass regrowth from the PUCs was not possible in 2012 due to time and resource constraints. Efforts at annual bluegrass control in Aialik Bay should continue to be a high-priority, with the greatest chance of infestation control coming through one early season and one late-season EPMT trip to these sites each year.

Common Plantain (*Plantago major*) – AKNHP Invasiveness Ranking 44

Plantain is a very cosmopolitan invasive plant that inhabits human-disturbed areas across the world. At KEFJ it is familiar and ubiquitous, though a very sporadic and easy-to-control plant. Individual plants have been mapped and controlled in all areas that see human impact including all the lower trails, the HIT below Marmot Meadows (1.6 miles), around buildings, bordering the parking lots and road, and at the maintenance facility. Individual plants are likely the result of seeds carried in on visitors' clothing and gear, or to viable seeds still remaining in the soil. Occasionally more dense patches of plantain can be found. These infestations most likely occur where a plant was missed and not controlled in the previous season and went to seed.

Exit Glacier Road, Trails, and Facilities

Sporadic individual plants were mapped and controlled, as found, throughout the season in 2012, from June through September. Slightly more dense stands were found along the road, near the 1889 moraine, at a switchback on the northern end of the Overlook Loop Trail, and on a discontinued section of the old Harding Icefield Trail. These higher density infestations are most likely the product of plants missed in 2011, or in the case of the infestation on the old HIT, overlooked and not controlled for a number of years.

Figure 12. Robust plantain (*Plantago major*) plant in full flower.

Maintenance Yard

Plantain was found sporadically across the maintenance yard in 2012, with most plants found along the east and north fence lines, and near the main building. These plants represent a high priority for EPMT because of the likelihood that seeds that develop here could be readily introduced into the park.

Outer Coast

The only place that plantain has been identified on the outer coast is at the Kenai Fjords Glacier Lodge staging area on Pedersen Beach. Very few individual plants were found, and they are likely the result of seeds brought in by visitors. 100 percent of plantain plants encountered in 2012 were mapped and fully controlled.

Pineapple Weed (*Matricaria discoidea*) – AKNHP Invasiveness Ranking 32

Pineapple Weed, like common plantain, is widespread and common throughout the lower trails at Exit Glacier and at the maintenance facility, but it rarely is found in dense patches. Individual seedlings of pineapple weed begin to emerge and become recognizable in July and early August, and are easy to control, even with a small crew, prior to setting seed. The consistency of their emergence attests to how common pineapple weed is in human inhabited areas outside of the park, and to the transport of seed propagules into the park by visitors.

Exit Glacier Road, Trails, and Facilities

Sporadic individual plants were mapped and controlled around the parking lot, near Alder cabin, around the Nature Center and on all the lower Exit Glacier Trails. All plants were identified and removed at an early stage of growth. Notably no pineapple weed plants were found on the HIT in 2012.

Maintenance Yard

The only location in KEFJ that pineapple weed occurs in densities greater than as intermittent individuals is in the northeast corner of the park's maintenance yard, a well-known and persistent infestation. Even this infestation is easy to control with minimal manpower, and should continue to be a high priority for treatment.

Outer Coast

Pineapple weed was first identified in 2011 at the Kenai Fjords Glacier Lodge staging area on Pedersen Beach in Aialik Bay. This is a high priority infestation due to the risk of further spread into pristine areas on the outer coast by lodge visitors. The pineapple weed here, as well as the annual bluegrass and plantain it is associated with, was manually controlled to 100 percent effectiveness by four people in less than 1.5 hours.

White Clover (*Trifolium repens*) – AKNHP Invasiveness Ranking 59

Exit Glacier Road and Parking Lot

Each year the KEFJ EPMT finds and controls a small number of sporadically occurring white clover plants with less than 20 plants found in the park in 2012. All clover plants were found in the fill directly alongside Exit Glacier Road or in the parking area. Plants are typically found in the same location as plants controlled in previous years. This attests to clover's ability to readily resprout from any remnant of their web-like tangle of roots. Diligence in control has kept this invasive plant from becoming the pervasive problem that it is in most developed areas of the world. Complete control of this species should continue to be a high priority to the EPMT because its extent remains very small and easy to manually control with simple hand digging tools.

Figure 13. Control of white clover (*Trifolium repens*) in the Exit Glacier parking lot.

Common Timothy (*Phleum pretense*) – AKNHP Invasiveness Ranking 54

Common Timothy grass is difficult to identify because it is usually found growing alongside other grass species including Alpine Timothy (*Phleum alpinum*), a native plant common to many areas of KEFJ that looks very similar to Common Timothy prior to flowering. Common Timothy

typically begins to flower here in early July, with some plants flowering up to a month later. Multiple returns to infestations mapped in 2011 were required in 2012 to effect complete control.

Exit Glacier Road and Parking Lot

A number of small infestations occur along Exit Glacier Road on the north side of the road slightly west of the entrance sign. These infestations, with one exception, showed a marked decrease in size and density over the previous year which attests to the general effectiveness of manual control on this plant. One infestation, missed in 2011 due to brushing by the maintenance crew and removal of the identifying flowering tops, was by far the largest and most dense infestation found in 2012. From this single 6 foot long infestation over 27 pounds of Common Timothy was removed, more than in all other infestations combined.

Figure 14. Dense stand of common timothy (*Phleum pretense*) controlled in 2012.

Outer Coast

The isolated infestation of Timothy on the outer coast at the Beauty Bay airstrip could not be found after extensive searching in 2012. While this does attest to the effectiveness of control operations, it does not mean the infestation has been completely eradicated. The area has dense populations of native Timothy grass, which make identification short of full-flower very difficult. It is likely that the plants were in an early phenological stage in 2012 due to the deep and long-lived snows of winter, and may be identifiable at the same location in future years. Future monitoring of Common Timothy at this location should be based on historical GPS data.

Sheep Sorrel (*Rumex acetosella*) - AKNHP Invasiveness Ranking 51

Sheep sorrel is found in KEFJ in very small and isolated, but persistent, populations. Two small infestations on the northern edge of the Exit Glacier parking area are returned to annually by KEFJ EPMT, and are usually found in numbers of less than 20 stems. Manual control, while effective at keeping these infestations from expanding, must be conducted very carefully and thoroughly to remove as much of the rhizomatous roots as possible. Delicate rhizomes can often be worked out of the top soil in lengths up to a few feet long, and top growth can sprout anywhere along its length.

Exit Glacier Parking Lot

In 2012 the distinctive, but very small leaf structures were first recognized and the plant was controlled in early July. Regrowth and a newly discovered nearby infestation along the road between the winter pit-toilets and the Nature Center was controlled again on July 30. It is

advisable that future EPMT crews conduct multiple inspections of sheep sorrel infestations due to their ability to resprout quickly from tiny root fragment remnants.

Curly Dock (*Rumex crispus*) – AKNHP Invasiveness Ranking 48

Curly dock is a water-loving plant that often infests disturbed areas, wet roadsides, and ditches, but luckily is present in extremely small numbers in KEFJ.

Employee Housing

One infestation, known of and returned to for many years by the park EPMT, is just south of the deck of Willow cabin (employee housing). No plants were found in 2012, but the infestation should continue to be considered a very high priority for EPMT staff until many years of no plants found can reasonably indicate that the seed source has finally been exhausted.

Outer Coast

Another, larger infestation is located along the beach and the beginning of the Aialik Public Use Cabin access trail and was first identified in 2011. This infestation of only 2.5 meter diameter was controlled for nearly 100 stems in 2012. The substrate of this area is large beach cobbles, which make complete removal of the long taproots difficult. The quantity of small plants also indicates that there is an ample seed source still viable on this site. It should be returned to annually, and receive high control priority for the EPMT.

Mouse-ear Chickweed (*Cerastium fontanum ssp. vulgare*) - AKNHP Invasiveness Ranking 36

Mouse-ear Chickweed, while not highly invasive, has shown a slow increase in infestation area since first being mapped at Exit Glacier in 2010. This plant occurs in low-densities and is very easy to control manually, but is difficult to locate without a concerted effort due to its low stature and small size.

Exit Glacier Trails and Facilities

Mouse-ear Chickweed is spreading along the Main Trail, especially on its eastern end, and near the Nature Center. These plants are hard to identify as they are low-growing and typically are found in grasses and other vegetation at the edge of trails. They were not identified or controlled in 2012 until most of the plants had already gone to seed. Because mouse-ear chickweed and annual bluegrass grow in many of the same areas and are late-season flowerers, it is advisable that future control efforts along the Main Trail focus on both species simultaneously.

Maintenance Yard

The northeast corner of the maintenance yard contains one low-density infestation of mouse-ear chickweed. As in other areas of the park, these plants are found growing in and near other plants and grasses which makes identification difficult.

Common Chickweed (*Stellaria media*) – AKNHP Invasiveness Ranking 42

2012 marks the first year that common chickweed, a very cosmopolitan species common in many parts of the world, was mapped and controlled in KEFJ. It is likely that this plant has been present within park facilities before 2012, but was in small enough quantities to avoid detection.

Maintenance Yard
In 2012 an infestation of over .25 acre in area with up to a 25 percent chickweed cover was identified on the western side of the maintenance yard. Efforts to manually control the infestation, with the help of a six-person SAGA crew proved insufficient to quantifiably reduce population numbers before the plants had gone to seed in August. This site needs to be considered a high priority due to the rapidity of its establishment, the density of the infestation, and the risk of park equipment working in the maintenance area spreading the plant into the park. Alternative methods of control should also be considered due to the monoculture-like habit of its growth. Other control techniques that should be considered include early season burning, raking, or shoveling. These methods may prove more effective than hand-pulling plants stem by stem which proved insufficient in 2012.

Prostrate Knotweed (*Polygonum aviculare*) – AKNHP Invasiveness Ranking 45

2012 marks the first year that prostrate knotweed was identified on KEFJ lands. The common name Prostrate Knotweed refers to its flat-growing, mat-forming habit. It shows a preference for highly disturbed habitats and has a very low likelihood of spread into undisturbed ecosystems. Because it occupies a very small area, and is readily identified and controlled, it should continue to be swiftly managed by the EPMT.

Maintenance Yard
Prostrate Knotweed was found growing in the northeast corner of the maintenance yard in the same site that also harbors dandelion, plantain, pineapple weed, annual bluegrass, mouse-ear chickweed, and common chickweed. More than any other location on KEFJ land this area, about 50 square meters in size, has the greatest diversity of invasive plants. EPMT found a small number of knotweed plants, about 10 stems, in 2012. Prostrate Knotweed should be identified by EPMT and controlled early, before it becomes another established plant of high concern.

Figure 15. Prostrate knotweed (Polygonum aviculare) found growing in the maintenance yard.

Yellow Toadflax (*Linaria vulgaris*) – AKNHP Invasiveness Ranking 69

Yellow toadflax has been a high-priority for treatment since the first year of the park EPMT in 2004. This species, a commonly planted ornamental, has become established in disturbed sites across North America, and is very common in the nearby town of Seward. Well-established infestations are extremely difficult to control due to their rhizomatous habit, ability to regrow from the tiniest of root fragments, and abundant production of seeds.

Exit Glacier Road

KEFJ EPMT has been controlling a population of yellow toadflax on the south side of Exit Glacier road, across from the park entrance sign, annually since 2004. At that time the infestation was a nearly continuous swath extending for 145 meters (Kriedeman 2004). Manual efforts, very difficult for this plant once fully established, have proven extremely effective at KEFJ. In 2012, after returning to the area on six different occasions from late June into September, no stems of the plant were found. It should not be inferred that this infestation is fully eradicated due to the plant's ability to regrow from seeds that remain viable for years, and its pervasive ability to resprout from tiny root fragments. Occasionally, when a population has been reduced to very small extents it does not fully emerge on certain years due to environmental conditions. 2012 in KEFJ showed a very late plant phenology, and the site of this infestation has been subject to annual flooding. It is possible that a combination of phenology, flooding, and other factors caused the yellow toadflax not to emerge this season. EPMT should continue to search for emergent stems of this plant using historical GPS data from 2011, as well as from previous years with greater infestation extents. Additional factors that might influence the growth and spread of this infestation relate to the annual flooding and planned flood-mitigation roadwork. While flood scouring, and new fill material could potentially bury, erode, and effectively remove the infestation, these actions could just as easily promote the plants' spread into other areas through removal and redeposition of infested soil.

Table 2. Presence of invasive species by location, and control efforts by KEFJ EPMT in 2012.

Invasive Plant Species and Infestation Sites in and near Kenai Fjords National Park

Species: / **Locations:**	Taraxacum officinale	Poa annua	Plantago major	Matricaria discoidea	Trifolium repens	Rumex acetosella	Rumex crispus	Cerastium fontanum	Stellaria media	Phleum pretense	Linaria vulgaris	Leucanthemum vulgaris	Poa pratense	Vicia cracca	Melilotus alba	Medicago sativa
Exit Glacier Area :																
Harding Icefield Trail	X	X	X													
Edge of the Glacier Trail	X	X	X	X												
Glacier View Trail	X		X													
Main Trail	X	X	X	X				X								
Nature Center area	X	P	X	X	X	X		P	X				Z			
Public Parking Lot	X	N	X	X	X			N		X		Z	Z			
Employee Housing	X	X	X	X			Z									
Campground (and parking)	X	X														
Exit Glacier Road (within park)	P	N	X	X	X					X	Z	Z				
Exit Glacier Road (outside park)	N	N	N	N	N							P		X	P	P
Outwash Plain	C															
"Nike Stripe"	C															
Maintenance Facility	X	X	X	X	X			X	P							
Outer Coast :																
Beauty Bay	X															
Dinglestadt Cliffs	X															
Holgate Public Use Cabin		X														
Aialik Public Use Cabin		X					X									
Pedersen Lodge Kayak-beach		X	X	X												

Key to Symbols:

X : Present and manually controlled by KEFJ EPMT staff.

N : Present and not controlled by KEFJ EPMT staff.

C : Present and chemically controlled by KEFJ EPMT staff.

P : Present and partially controlled by KEFJ EPMT staff.

Z : Historically found and controlled by KEFJ EPMT staff, but not found in 2012.

U : Unverified historical account of presence, but not found by KEFJ EPMT staff.

(no symbol; blank) : Not present.

Community Outreach and Invasive Plant Control Beyond Kenai Fjords

Beyond park boundaries, other agencies such as the Chugach National Forest, and groups such as the Resurrection Bay Conservation Alliance (RBCA), and the Alaska Association of Conservation Districts (AACD) control the Exit Glacier roadside for invasive plant species. KEFJ EPMT collaborated with these groups in a Community Weed Pull event held on the 21st of June. In 2012 the event drew 6 NPS staff, 5 USFS employees, 8 SCA volunteers, 11 volunteers with the Mike Woods service group from Anchorage, Alaska and one member each from RBCA and Alaska Association of Conservation Districts. Working together at a number of sites along Exit Glacier Road, the crews succeeded in removing oxeye daisy (*Leucanthemum vulgaris*) from the Forest Service pull-out just east of the National Park boundary, significant amounts of tall alfalfa (*Medicago sativa*) from the Exit Glacier viewpoint and from the Forest Service entrance pull-out, the lone infestation of bird vetch (*Vicia cracca*) at the Forest Service entrance pull-out, and significant amounts of dandelions from the entrance to the Resurrection River Trail. In all 172.5 pounds of invasive plants were removed from the road system in one day.

Figure 16. SCA volunteers, the Mike Woods service group, RBCA, Alaska Association of Conservation Districts members, and EPMT at the 9th annual Exit Glacier Road Community Weedpull event.

The park EPMT also participated as a crew in two community restoration and invasive plant control projects in the nearby town of Seward. On June 26 seven staff members from KEFJ joined the RBCA, a number of Alaska Sea Life Center volunteers, and SCA volunteers from Palmer, Alaska participated in a stream bank restoration project to improve a fragile salmon-spawning lagoon near the Seward small boat harbor. Wattles were placed between the bank and the lagoon, backfilled with salvaged gravel and imported top soil, and planted with a lattice of native shrubs, particularly alders and willows. The resulting revegetated stream bank has shown strong growth, is reducing sediment runoff and erosion into the creek, and discourages trampling from people.

On June 30 the Kenai Cooperative Weed Management Area hosted an event at the Seward Middle School, the annual Seward Weed Smackdown. Many volunteers from across Southcentral Alaska came out to lend a hand in manual control of a bird vetch infestation at the Seward Middle School. The EPMT made a uniformed presence, contributed enthusiastic manpower, and connected with other citizens concerned about the issue of invasive plants in Alaska.

In 2012 KEFJ sponsored one SCA volunteer dedicated to invasive plant education. This position coordinated service groups for educational and work-experience based multi-day projects in the park. The Mike Woods service group from Anchorage, Alaska visited from the 19th through the 21st of August, 2012, and participated in the Community Weedpull event on the 21st. These educational exchanges provide the service groups education and experience in the workings of National Parks, and provide the park with motivated hands to help in project work, and to spread the National park's mission beyond NPS boundaries. When not leading service groups or serving as an interpretive ranger, the invasive plant education intern would join the EPMT in conducting field work in the Exit Glacier area and on the outer coast.

Discussion

Despite its easy accessibility and proximity to areas heavily infested with non-native species, KEFJ is remarkably free of invasive plants. The park is in a unique position to prevent large scale infestations of invasive plants through early detection and rapid response. Quantities of exotic species, and the numbers and sizes of infestations are much smaller in KEFJ than in many other parks is in Alaska. Throughout the nine year history of the EPMT program at KEFJ the greatest amount of effort has been devoted to the control of common dandelion, the most abundant and widely distributed non-native plant species within the park. Dandelion has been shown to readily colonize disturbed areas, and to rapidly obtain vegetative dominance, sometimes crowding out native seedlings and even invading undisturbed areas (Weaver et al. 1990). In places like KEFJ, where retreating glaciers are continually exposing freshly disturbed land, the control of exotic plants is crucial to maintaining the ecological integrity formed through the natural process of plant succession.

Table 3. Invasive plant species documented within Kenai Fjords National Park. Bold print indicates presence in 2012. Invasiveness ranking based on Invasiveness Ranking System for Non-Native Plants of Alaska (Carlson 2008).

Taxon	Common Name	Invasiveness Ranking 9/2012
Linaria vulgaris	yellow toadflax	69
Hordeum jubatum	foxtail barley	63
Leucanthemum vulgare	oxeye daisy	61
Trifolium repens	**white clover**	**59**
Taraxacum officinale* ssp. *officinale	**common dandelion**	**58**
Trifolium hybridum	alsike clover	57
Crepis tectorum	narrowleaf hawksbeard	56
Phleum pratense	**common timothy**	**54**
Ranunculus acris	tall buttercup	54
Trifolium pratense	red clover	53
Poa pratensis	Kentucky bluegrass	52
Alopecurus pratensis	meadow foxtail	52
Rumex acetosella	**common sheep sorrel**	**51**
Brassica rapa	field mustard	50
Rumex crispus	**curly dock**	**48**
Poa annua	**annual bluegrass**	**46**
Polygonum aviculare	**prostrate knotweed**	**45**
Plantago major	**common plantain**	**44**
Stellaria media	**common chickweed**	**42**
Cerastium fontanum	**mouse-ear chickweed**	**36**
Matricaria discoidea	**pineapple weed**	**32**
Agrostis gigantea	red top	unranked
Aquilegia spp.	columbine spp.	unranked
Papaver nudicale	Icelandic poppy	unranked

Species ranking based on the Invasiveness Ranking System for Non-Native Plants of Alaska (Carlson et al. 2008).
Species in **bold** were observed in the park in 2012.
Species in normal font have been observed in the park but were not observed in 2012.

To date there have been 24 documented non-native species found within KEFJ (eleven species found in 2012), and at least 16 additional species growing just outside the park (Rapp, 2009). Currently no species found within KEFJ ranks higher than 69 on the Alaska Natural Heritage Program's invasiveness rating system, and the highest rated invasive plant, yellow toadflax, has had its population effectively reduced by EPMT over the years such that no stems were found in 2012. There are a number of aggressive and noxious invasive plant species including white sweetclover (ranked 89), bird vetch (73), and oxeye daisy (61) found within a few miles of the park boundary along Exit Glacier road. Other, highly invasive species, such as reed canarygrass (*Phalaris arundinacea*, 83), orange hawkweed (*Hieracium auranticum*, 79), European Mountain Ash (*Sorbus aucuparia*, 59), common tansy (*Tanacetum vulgare*, 57), and creeping buttercup (*Ranunculus repens*, 54) are found in the nearby town of Seward, growing in yards and near state highways where their seeds can be easily transported into new areas. Diligent effort must be continued to keep these, and other, invasive plant species from compromising the ecological integrity and natural diversity of KEFJ.

Recommendations

Invasive plant management is an ongoing process as every year has the potential for new invasive plant seeds to be introduced by natural processes such as wildlife, winds, and floods, and through human influence by being inadvertently carried in with park visitors. It is important that KEFJ maintain the current low levels of invasive plant infestation through early detection and rapid response to small populations, and continued monitoring and control efforts on larger, more established populations in order to contain, reduce, and potentially eradicate them. Preventative measures, such as the boot brush installation at the Exit Glacier Nature Center, are effective ways to educate the public about invasive plants and to reduce seed introduction into more pristine areas of the park.

The park EPMT should continue to work with volunteer crews, scientists and other park divisions to educate them about the best management practices to avoid the introduction and spread of invasive plants into the park while working here. This includes presentations by EPMT to volunteer crews when they first arrive at the park, presenting information to KEFJ staff during their preseason training, and including mitigation measures in scientific research permits to reduce invasive plant introduction. Frequent interactions between interpretive staff members and the EPMT are encouraged in order to inform and educate park interpreters about EPMT work within the park and invasive plant control concepts in general. The interpretive staff is in a unique position to spread information about invasive plant control to park visitors which can enhance the public recognition and success of EPMT work.

The effectiveness of chemical control in invasive plant management at KEFJ should continue to be monitored and considered as a means of treatment. The Exit Glacier outwash plain and Nike Stripe should be revisited to monitor the effectiveness of herbicide applications on common dandelion. Changes to herbicide treatment methods to consider for 2013, based on their effectiveness in 2012, include the concentration of herbicide component in herbicide mixture and coverage rate per area of prepared mix. Exit Glacier Road should be considered for herbicide treatment in appropriate areas in 2013. This extensive infestation of common dandelion is beyond the capacity of manual control in its current extent and density, and is spreading beyond the road corridor into undeveloped areas. Proper use of herbicide along the road could significantly increase the EPMT's ability to reduce and fragment this infestation. Areas outside the scope of chemical treatment, wet sites and streamside sections, will then become isolated and small enough for future manual control.

The Dinglestadt Cliffs infestation of dandelions, on the outer coast in McCarty Fjord, is a major priority for EPMT control work due to its isolated position in an otherwise pristine habitat. Conducting control work here is very resource intensive requiring a crew of four or more people to travel to the area by boat, a six-hour trip each way, followed by most of an 8-hour work day travelling off-trail to the infestations and doing manual control work. This infestation should be considered for chemical control to decrease the time involved in control operations, to increase the effectiveness of the control, and to increase the potential of eventual eradication of this dandelion population. The plants, growing on a high and dry site, with individuals rarely becoming robust due to environmental constraints, are likely to respond quickly to herbicide.

Efforts at controlling and reducing annual bluegrass populations within the park should continue, to maintain the relatively low abundance of this plant in the park. Control efforts should be focused on the Exit Glacier trails, the HIT, Main Trail, and the Overlook Loop, and at remote infestations on the outer coast such as the Aialik Bay PUCs and the Kenai Fjords Glacier Lodge staging area on Pedersen Beach. Efforts around the Nature Center and other front country areas should be conducted as time and labor allow. All other, less abundant species should continue to receive swift and thorough treatment throughout the park in order to keep them from becoming large and established populations.

Non-native plant disposal is an ongoing issue. At KEFJ this is currently done by bagging pulled weeds and disposing of bags at the local dump where they are then removed to an area landfill. Invasive plants are very prolific seeders, with a single dandelion plant able to produce up to 5,000 seeds (Royer and Dickinson, 1999), and many species, including dandelion, able to produce fully viable seeds even after being pulled from the ground or torn into smaller pieces. Until a complete disposal method is devised, one which fully destroys plant material and renders their seed non-viable, all controlled plant materials are high risk vectors to further spread exotic plants into new areas. Methods that have been tried by other parks, including composting and incineration, are still not of determined effectiveness, and are cost or labor prohibitive. Further research should be devoted to this subject, and cooperative waste-management strategies with partner groups and agencies should be considered.

Activities and programs focused on community outreach should continue to be a priority. Outreach efforts to the local community of Seward include distribution of educational information about invasive plants, invasive plant control events on area roads, parks and trails, and revegetation efforts in the area. Local partner groups, including Alaska Association of Conservation Districts (AACD), Resurrection Bay Conservation Association (RBCA), and the Chugach National Forest provide opportunities for the EPMT to collaborate on projects and events, and as means to share and disseminate information to the general public.

Figure 17. Bagging and weighing weeds controlled during the Community Weedpull event.

Efforts at impact mitigation on native vegetation should be increased in coordination with the KEFJ trail crew. EPMT efforts at early season trail marking have proven an effective way to keep hikers from venturing off trail and into fragile alpine vegetation where they damage native plants as well as running the risk of introducing non-native species. Revegetation of trail impacts and abandoned trail sections should be conducted in collaboration with the trail crew who maintains a larger work force and has an intimate awareness of trail conditions and project work. Late season seed

collection work, conducted in 2012 with the assistance from members of the Alaska Plant Materials Center, should continue in future years to provide seed for future restoration projects. Seed can then be used in park revegetation efforts as a complement to salvaged plants, and when no other plant material is available.

European and Asian Gypsy Moth monitoring should continue to be conducted by the EPMT staff. With similar vectors of introduction as invasive plants, and their potential harmful effects on native vegetation, the Gypsy Moth project is complementary to EPMT work. With the small amount of time required to establish and monitor these moth traps, park staff will be better assured that this potentially devastating species does not pose an immediate threat to the area.

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Appendix A:

Gypsy moth monitoring at Exit Glacier
Kenai Fjords National Park
2012
Deb Kurtz

Introduction

In 1869 the European gypsy moth (*Lymantria dispar*) and the Asian gypsy moth (*L. japonica*) were introduced from Europe to North America (Massachusetts) for possible silk production. Today they are well established in the eastern US with small populations in the western US (PA DCNR, 2011). Like many nonnative invasive species, gypsy moths pose a serious threat to forested ecosystems, including those in Alaska. Large populations of gypsy moth larvae can completely defoliate a hardwood tree which can eventually result in tree mortality.

Figure 1. European Gypsy Moths: female (top) and male (bottom).

Increased commercial activity and tourism as well as global warming trends increase the possibility that nonnative organisms introduced into Alaska will establish breeding populations and begin to spread (USDA, 2011). Moths are easily transported by tourists visiting from areas where gypsy moth populations are established by hitchhiking on human related items such as lawn furniture, recreational vehicles, ships, cars, containers, and camping equipment that has been in storage, and can arrive during any portion of their life cycle. Monitoring is imperative to detect an invasive species early and to be able to implement a cost-effective rapid response control measure. Although a few European gypsy moths have been captured during previous forest moth surveys, it is believed that this species has not established a reproducing population in Alaska to date (Knight, 2011, email).

Methods

2012 is the second year that the Alaska region national parks, coordinated by the Exotic Plant Management Team, helped the Alaska Division of Agriculture* conduct forest moth surveys. Monitoring in Kenai Fjords National Park (KEFJ) consists of setting five traps near potential areas of introduction (i.e. areas of high visitor use). Current monitoring efforts target the adult flying male moths. The traps are set to coincide with the moths' flight period which, in their native range, is generally between mid- June / mid-July to late August / mid-September. Historically, the captures in Alaska have occurred between late July and late August.

Figure 2. Moth trap located on the south side of the parking lot at Exit Glacier.

Four traps were hung around the parking lot at the Exit Glacier Nature Center and one trap at the parking lot at the park campground from mid-June through late September. The traps consist of waxed cardboard trapezoids lined with a

sticky coating. A string coated with female gypsy moth pheromones is stapled to the inside to lure adult male moths inside the trap where, in theory, they would get stuck in the coating that lines the inside of the trap. The traps are checked once a month and data is entered into a GPS for efficient data management.

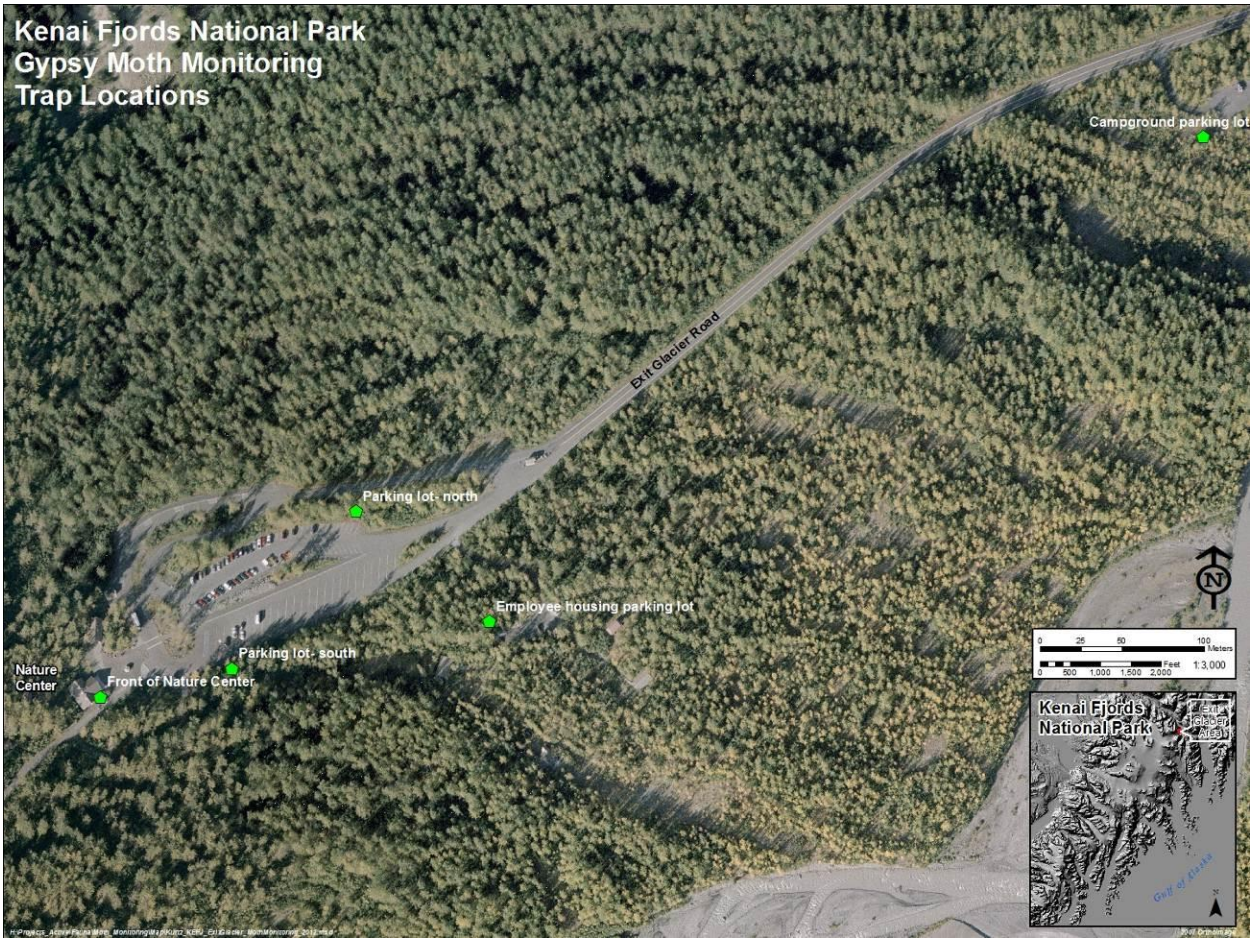

Figure 3. Five traps were set in the Exit Glacier area of Kenai Fjords National Park to monitor for European gypsy moths.

Results

No gypsy moths were observed in the traps during the 2012 field season. It appeared that there was much less bycatch (mostly mosquitoes and flies), compared to the 2011 season.

Conclusions and Recommendation

No gypsy moths were observed in the traps at the Exit Glacier area during the 2012 field season. KEFJ staff should continue to monitor for this nonnative species as part of an early detection and rapid response effort. The monitoring effort is simple, requires little time, is non-intrusive, and provides park managers with additional information to effectively manage the park.

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*Numerous agencies have programs in place to monitor and detect potential insect introductions in Alaska including: USDA Animal & Plant Health Inspection Service Plant Protection and Quarantine (APHIS-PPQ), the State of Alaska Department of Natural Resources- Divisions of Agriculture and Forestry (ADNR DOA, DOF), University of Alaska Cooperative Extension Services (CES), National and Western Plant Diagnostic Network (NPDN, WPDN, both include insects), Customs and Border Protection (CBP), and the USDA Forest Service Health Protection (USFS-FHP).