



Invasive Species Management for Katmai National Park & Preserve, Alagnak Wild River, and Aniakchak National Monument & Preserve

2015 Summary Report

Natural Resource Report NPS/KATM/NRR—2015/1096





ON THE COVER

A native horned dandelion (*Taraxacum ceratophorum*) discovered on an island in Research Bay. Photo by M. Armstrong

Shepherd's purse (*Capsella bursa-pastoris*) on the spit at Brooks Camp. Photo by J. Tourville

2015 EPMT campsite at the Katmai National Park and Preserve. Photo by M. Armstrong

INSIDE COVER

Tundra vegetation on the Buttress Range overlooking the Windy Creek drainage in the Valley of Ten Thousand Smokes.

Photo courtesy Crystal Brindle

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Abstract

2015 marked the sixth season that the Alaska Exotic Plant Management Team protocol was followed throughout the season to survey and control invasive plants in Katmai National Park & Preserve (KATM). This year, field work focused on inventorying new sites and monitoring sites that had not been visited in several years. New sites included the Alagnak Wild River and Hamersley Lake, and massive expansions to previously surveyed areas included Grosvenor, Kukaklek, and Mirror

Lakes, and Amalik and Hallo Bays. Informal visual surveys for *Elodea* were a top priority after its discovery was confirmed in Lake Hood, a primary hub for float plane traffic to and from Alaska's parks. There was no evidence of any infestations of *Elodea* in KATM. Mechanical and chemical treatment was executed on large known infestations at Brooks Camp, the Valley of Ten Thousand Smokes Road, Lake Camp, Fure's Cabin, Nonvianuk Ranger Cabin and administrative areas in King Salmon. *Taraxacum officinale* (common dandelion) at Fure's Cabin and *Rumex acetosella* (sheep sorrel) at Lake Camp were treated with Milestone herbicide. Manual control continues to be the standard treatment at most sites in Katmai as it has proven successful for small infestations such as the cultural site at Brooks Camp. Compared to infestations found within the contiguous United States, Katmai National Park maintains the distinction of containing healthy, intact native ecosystems with very low levels of infiltration by invasive plants. Preventive measures like education and outreach, and monitoring of Katmai's current and upcoming construction projects will be essential in preserving the health and native beauty of the park.



Figure 1. Informal surveys for *Elodea* in KATM's waters were a new focus for the 2015 EPMT.

Acknowledgments

We would like to thank our supervisor, C. Turner, for her leadership, management and helpful insights this year. Thank you to those responsible for transporting us to more remote areas of the park: A. Gilliland for flying us around the park; R. Peterson for guiding us through the wilderness; and SWAN team members K. Bartz, E. Booher, and J. Nelson for letting us join them for aquatic surveys. We thank our leadership and technical staff at the Alaska Regional Office: C. Overbaugh and P. Frank; thank you for an informative orientation in May, your constant availability, your help in the field, and your assistance with our data analysis, and proofreading. Thank you to our volunteers A. Hutchinson and I. Ronan for your hard work this season. Thank you to a multitude of Natural Resources and Interpretive staff who made the work and Alaska experience exceptional. Thank you also to the US Fish and Wildlife Service staff who assisted with our work in King Salmon. Lastly, we thank the SCA and AmeriCorps for giving us the opportunity to do what we love in a place we have come to love.

Abbreviations

AKEPIC Alaska Exotic Plants Information Clearinghouse
AKEPMT Alaska Exotic Plant Management Team
AKNHP Alaska Natural Heritage Program
ALAG Alagnak Wild River
ANIA Aniakchak National Monument & Preserve
APCAM Alien Plant Control and Monitoring
BCDA Brooks Camp Developed Area
EPMT Exotic Plant Management Team
FAA Federal Aviation Administration
FWS Fish and Wildlife Service
GPS Global Positioning System
KATM Katmai National Park & Preserve
KSVC King Salmon Visitor's Center
NPS National Park Service
SAGA Southeast Alaska Guidance Association
SCA Student Conservation Association
SWAN Southwest Alaska Network
USGS US Geological Survey
VRAA Valley Road Administrative Area
VTTSR Valley of Ten Thousand Smokes Road
VTTS Valley of Ten Thousand Smokes

Introduction

Katmai National Park & Preserve

Katmai National Park and Preserve, Alagnak Wild River (ALAG), and Aniakchak National Monument and Preserve (ANIA) encompass 4.1 million square acres of nearly pristine wilderness. Located at the base of the Alaskan peninsula, Katmai features a wide variety of habitat including low lying tundra, turbid freshwater river systems, and rugged snow-capped mountains and volcanos. The park was founded in 1918, after recognition of the unique geological features formed from the Novarupta volcanic eruption of 1912, the world's largest volcanic event of the 20th century. Over time, the park has also become known for its wildlife. The more conspicuous among these include brown bears, salmonoid fish, and marine and terrestrial birds.

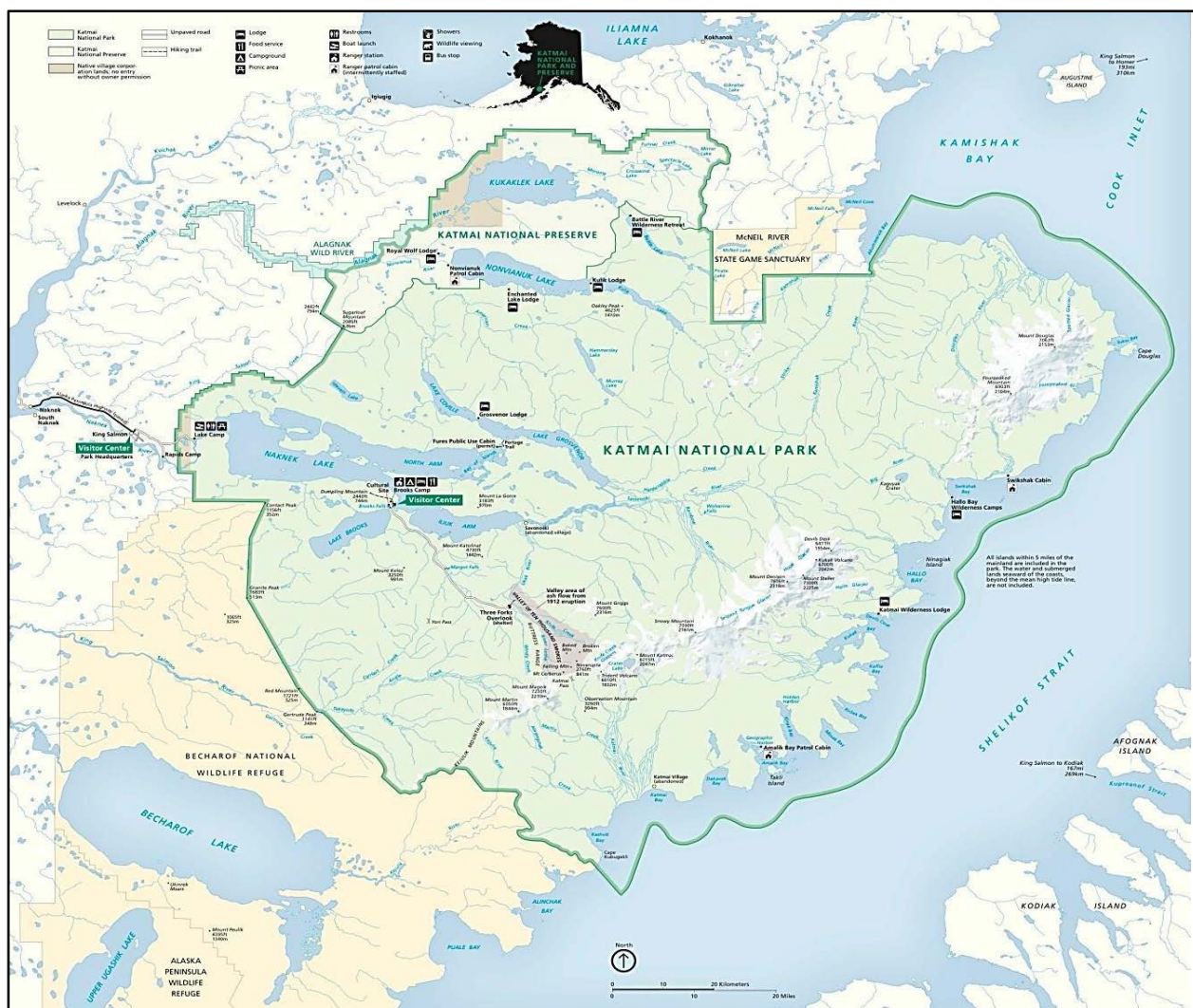


Figure 2. Map of Katmai National Park and surrounding areas.

While Katmai is one of the larger parks in Alaska, its remote location makes it one of the least visited in terms of total number of guests per year. Most go to Brooks Camp which boasts a huge density of brown bears every summer. Brooks Camp also provides access to the Valley of Ten Thousand Smokes (VTTTS) via the VTTTS Road. Outside of Brooks Camp, many visitors travel to the Katmai Coast for bear viewing and fishing; Hallo and Amalik Bays experience the most traffic out of all coastal sites.

Invasive Plant Ecology and Management

Invasive plants are a threat not only to native ecosystem functioning and biodiversity, but to local and regional economies as well. Here we define an invasive species as a non-native species whose populations have the ability to successfully reproduce and spread in a novel environment away from their point of introduction (Richardson et al. 2000). In addition, many invasive species cause environmental and economic damage directly impacting humans (Simberloff et al. 2005).



Figure 3. Fall dandelion at Lake Camp

In ecological terms, invasive plant species have impacts on multiple organismal scales. At the genetic level, invasive plants can hybridize with native congeners to the detriment of the native species (Rhymer and Simberloff, 1996). At the population level, increased competition from invasive plants can stress native populations, leading to a decline in the overall fitness of native plant populations (Leicht-Young et al. 2009). At the regional and global ecosystem and community levels, invasive plant species have the

ability to completely alter the composition of community assemblages (Callaway and Maron, 2006). A general

observation has been that invasive plants tend to homogenize environments and contribute to an overall loss of biodiversity (Olden and Poff, 2003). It is thought that a less biodiverse community is more susceptible to species extinction, and less able to resist the spread of invasive plant species. Lastly, the ranges of many invasive species are expected to shift under future climate change regimes. Expansion of invasive species distributions into novel regions has the potential to cause increased ecological damage to naïve native communities, especially at higher latitudes (Hellmann et al. 2008).

The economic impacts of invasive plant species are more tangible and more frequently used for policy and management decisions. Invasive plants can act as agricultural pests, reducing crop yield and herd numbers (Vila et al. 2010). Additionally, invasive plants can dominate habitats, making them less desirable as tourist destinations (i.e. US National Parks). It is estimated that the United States loses \$120 billion a year to invasive species and the majority of that is from invasive plants (Pimentel et al. 2005). Control and management efforts add to a considerable sum of this total. Current management strategies include manual treatment efforts, chemical control, and biological control.

Katmai EPMT Survey and Management History

To meet the growing challenge of invasive plant species, the NPS created the EPMT Program in 2000. The central goal of this program is to form small mobile specialist strike teams to quickly detect and remove invasive plants throughout the park system. This program currently includes 17 teams throughout the country. KATM is serviced as part of the Alaska EPMT (AKEPMT).

Global Positioning System (GPS) data showing the extent of invasive plant infestations in Katmai were first collected by the US Geological Survey (USGS) in 2000. Data was collected by the EPMT in 2005 for synthesis into three databases: the Alaska EPMT geodatabase; Alien Plant Control and Monitoring (APCAM), a nationwide NPS database for invasive plant data; and the Alaska Exotic Plants Information Clearinghouse (AKEPIC), a multi-agency database and mapping application providing geospatial information for non-native plants in Alaska and the Yukon run by the Alaska Natural Heritage Program (Rapp, 2009). Surveys and control work have been conducted in earnest since 2005 by a variety of teams; from single volunteers to Tribal Civilian Corps (TCC) and Southeast Alaska Guidance Association (SAGA) crews (Bauder and Heys, 2005; Rapp, 2009). Since 2010, the work has been fielded by two Student Conservation Association (SCA) interns, and has expanded from highly trafficked Brooks Camp to remote areas like the Outer Coast.

Prevention is the most effective way to limit the spread of invasive plant species and has therefore been a priority for the Exotic Plant Management Team (EPMT). Beginning in 2011, the EPMT installed informational signs and boot brushes, and set a precedent for conducting regular inspections of construction vehicles. The KATM EPMT have also created a revegetation manual to be used in future project planning to minimize species introductions associated with construction or maintenance, and to effectively restore disturbed areas before they are colonized by invasive species. Each year, the KATM EPMT has hosted invasive species programs for children in the community at the King Salmon Visitor Center (KSVC), and they have worked with the U.S. Fish and Wildlife Service (FWS) on their September high school science camp. Additionally, the EPMT has been a consistent presence at Fishtival, a community event celebrating the end of the salmon season in Naknek, which provides the opportunity to engage directly with the community about issues of invasive plant awareness and the negative impacts of invasives.

The goal of the 2015 KATM EPMT crew was to provide the NPS and future EPMT's with recommendations and information that will assist control efforts and mitigate the impacts of invasive plant species. The EPMT approached invasive plant management on three fronts: manual and chemical control, prevention monitoring, and community outreach. Chemical and manual control work of heavily disturbed sites continued in 2015, while also expanding monitored areas to include previously unsurveyed lands as well as revisitation of sites that have gone unmonitored for several years. Informal visual surveys for *Elodea* were conducted by boat and on foot on all water bodies visited this season. Additionally, the 2015 EPMT crew participated in several community outreach events, and produced updated outreach materials and several new outreach products.

Methods

Fieldwork in KATM was conducted from May to September 2015 in accordance with the 2015 Alaska Field Protocol (Million et al. 2015). Most of the fieldwork was conducted by SCA interns Melissa Armstrong and Jordon Tourville under the supervision of KATM coastal biologist Carissa Turner and AKEPMT regional office coordinator Christopher Overbaugh. In July and August, several volunteers and other NPS staff assisted with survey work and manual control efforts in King Salmon, Brooks Camp, Naknek Lake, ALAG, and the Katmai Preserve.

Fieldwork consisted of surveying for invasive plant species in areas with the greatest anthropogenic visitation and disturbance. Focal points for survey and control work were Brooks Camp, Lake Camp, NPS property in King Salmon, the VTTS Road, the outer Katmai Coast, the Katmai Preserve and ALAG. Sites in King Salmon, Lake Camp, Brooks Camp, and the VTTS were visited on a monthly basis throughout the season, while most other sites were surveyed only once. The EPMT focused primarily on manual or chemical treatment; all surveyed or treated areas were mapped using a Trimble GeoExplorer Series GeoXT (3000 series) or GeoXH (6000 series) GPS unit equipped with a standardized Alaska EPMT data dictionary specific to KATM and run with the software TerraSync. Manual treatment was conducted on all infestations throughout the Brooks Camp Developed Area (BCDA), the VTTS Road, Lake Camp, Naknek Lake, Hallo Bay, the Nonvianuk Ranger Cabin, the FWS and NPS docks, and the maintenance yard in King Salmon. The annual species *Matricaria discoidea* (pineappleweed), manually controlled in the past, was not actively removed or mapped this year due to its large total area cover and low invasiveness rank. It was, however, mapped if found in a remote or new location. Herbicide treatments using the broad-leaf specific herbicide Milestone, with the active ingredient aminopyralid, was applied by Chris Overbaugh to control *Taraxacum officinale ssp. officinale* (common dandelion) at Fure's Cabin, and *Rumex acetosella* (sheep sorrel) at Lake Camp. Visual inspections of surveyed waterbodies were conducted to check for the presence of the aquatic invader, *Elodea*.

Results

Overview

Table 1. Annual summary of Katmai National Park & Preserve Exotic Plant Management.

Year	# EPMT Personnel	Field Season Length	Invasive Plant GPS Data (NPS Lands/Non-NPS Lands) per year		
			Acres Surveyed	Species Acres Infested ¹	Acres Treated ²
2005	2	6/20-6/29	174.325 (37.507)	6.622 (0.012)	0.076
2007	< 1	intermittent	5.198	0.526	0.495
2008	< 1	intermittent	6.112	0.495	0.495
2009	< 1	intermittent	3.071	0.631	0.083
2010	2	5/3-9/30	105.959 (14.527)	14.417 (0.276)	7.464 (0.276)
2011	2	4/25-10/25	37.562 (1.497)	8.626 (1.497)	3.650 (0.143)
2012	2	5/20-9/28	95.867 (7.576)	11.953 (3.351)	3.262 (0.072)
2014	2	5/1-10/20	46.872 (0.949)	1.160 (0.073)	0.559 (0.042)
2015	2	5/3-10/9	73.018 (23.984)	0.391(2.324)	0.162 (0.291)

¹ Acres infested represent the area of a mapped infestation multiplied by the percent cover of invasive plants in that mapped area.

² Acres treated represent the area of a mapped infestation multiplied by the percent cover of invasive plants in that mapped area and by the percent of the infestation treated.

Table 2. Invasive plant species observed by EPMT in KATM and Bristol Bay Borough.

Species			Invasiveness rank*	Within KATM						Within Bristol Bay Borough				
	Scientific Name	Common Name		BCDA	VTTs Road	Lake Camp	Fure's Cabin	Outer Coast	Other location	Near NPS HQ	NPS Yard & Float Plane Dock	FAA Housing	US FWS	Other location
Present on NPS lands	<i>Bromus inermis</i> ssp. <i>inermis</i>	smooth brome	62	O	-	-	-	-	-	O	-	O	-	X
	<i>Capsella bursa-pastoris</i>	shepherd's purse	40	X	X	O	O	-	X	X	X	X	X	X
	<i>Cerastium fontanum</i>	mouse ear chickweed	36	X	O	-	O	O	O	-	-	O	-	O
	<i>Crepis tectorum</i>	narrowleaf hawksbeard	56	-	X	-	-	-	-	X	X	X	X	X
	<i>Leontodon autumnalis</i>	fall dandelion	51	-	-	X	-	-	-	-	-	X	-	X
	<i>Matricaria discoidea</i>	pineapple weed	32	X	X	X	O	X	X	X	X	O	O	X
	<i>Myosotis scorpioides</i>	European forget-me-not	54	-	-	-	-	O	-	-	-	-	-	-
	<i>Plantago major</i>	common plantain	44	X	X	-	-	X	X	X	X	O	X	-
	<i>Poa annua</i>	annual bluegrass	46	O	O	X	O	O	O	X	-	-	-	-
	<i>Polygonum aviculare</i>	prostrate knotweed	45	X	-	X	-	-	-	-	X	-	X	X
	<i>Ranunculus repens</i>	creeping buttercup	54	-	-	-	-	-	-	X	X	-	X	X
	<i>Rumex acetosella</i>	common sheep sorrel	51	O	O	X	-	-	-	X	X	X	X	X
	<i>Stellaria media</i>	common chickweed	42	X	X	-	-	O	-	-	-	X	X	X
	<i>Taraxacum officinale</i> ssp. <i>officinale</i>	common dandelion	58	X	-	X	X	X	X	X	-	X	X	X
Detected only off NPS lands	<i>Trifolium repens</i>	white clover	59	O	-	-	-	-	-	X	-	X	-	X
	<i>Vicia cracca</i>	bird vetch	73	-	O	-	-	-	-	-	-	-	-	X
	<i>Alopecurus pratensis</i>	meadow foxtail	52	-	-	-	-	-	-	-	-	O	-	-
	<i>Caragana arborescens</i>	Siberian peashrub	74	-	-	-	-	-	-	X	-	-	-	X
	<i>Chenopodium album</i>	lambquarters	37	-	-	-	-	-	-	-	-	-	-	X
	<i>Galeopsis bifida</i>	split-lip hempnettle	50	-	-	-	-	-	-	-	-	-	-	X
	<i>Hieracium umbellatum</i>	narrowleaf hawkweed	51	-	-	-	-	-	-	-	-	-	-	X
	<i>Leucanthemum vulgare</i>	oxeye daisy	61	-	-	-	-	-	-	X	-	O	-	X
	<i>Linaria vulgaris</i>	yellow toadflax	69	-	-	-	-	-	-	-	-	-	-	O
	<i>Lotus corniculatus</i>	birdsfoot trefoil	65	-	-	-	-	-	-	-	-	-	-	O
	<i>Papaver nudicaule</i>	Iceland poppy	39	-	-	-	-	-	-	-	-	-	-	X
	<i>Phleum pratense</i>	common timothy	54	-	-	-	-	-	-	X	-	-	-	X
	<i>Prunus padus</i>	European bird cherry	74	-	-	-	-	-	-	X	-	-	-	-
	<i>Ranunculus acris</i>	tall buttercup	54	-	-	-	-	-	-	-	-	-	-	O
	<i>Rumex crispus</i>	curly dock	48	-	-	-	-	-	-	-	-	-	X	X
	<i>Securigera varia</i>	crownvetch	68	-	-	-	-	-	-	-	-	-	-	X
	<i>Sorbus aucuparia</i>	European mountain ash	59	-	-	-	-	-	-	X	-	-	-	X
	<i>Tanacetum vulgare</i>	common tansy	60	-	-	-	-	-	-	-	-	X	-	O
	<i>Trifolium hybridum</i>	alsike clover	57	-	-	-	-	-	-	X	-	O	X	X
	<i>Trifolium pratense</i>	red clover	53	-	-	-	-	-	-	X	-	-	X	X
	<i>Tripleurospermum inodorum</i>	scentless false mayweed	48	-	-	-	-	-	-	O	-	-	-	X
	<i>Viola tricolor</i>	johnny jumpup	34	-	-	-	-	-	-	-	-	-	-	X

X - Observed during current EPMT field season.

O - Observed during prior EPMT field seasons, but not documented this field season.

* Invasiveness rankings taken from AKNHP (<http://aknhp.uaa.alaska.edu/botany/akepic/non-native-plant-species-biographies/>) on 9/25/2015 with a value of 0 (low) to 100 (high) possible.

Brooks Camp

Brooks Camp, located at the mouth of the Brooks River, is the most heavily visited area in the park. Attracted by a range of activities from exploring the VTTS to bear-viewing at the famous Brooks River platforms, visitors from all over the world make this the most heavily infested area of KATM. *Taraxacum officinale* (common dandelion), *Plantago major* (common plantain), *Capsella bursa-pastoris* (shepherd's purse), *Poa annua* (annual bluegrass) and *Matricaria discoidea* (pineappleweed) are regular invasives each season in the BCDA.

The 2015 EPMT focused on manual control of the higher ranking invasives rather than inventorying all infestations, leaving annual bluegrass and pineappleweed unmapped and uncontrolled; neither will be referred to again unless they were found in a new remote location. All control work in the BCDA was manual, and inventory primarily occurred in June and August. July was spent surveying areas outside of the BCDA due to high levels of visitor use and bear activity. Due to the large extent of some of the infestations, the EPMT recommends the development of an herbicide application plan within the BCDA.



Figure 4. A map of the BCDA

BCDA Campground & Dumpling Mountain Trail

The Brooks campground is the only developed camping area in KATM and is frequented by hikers accessing the Dumpling Mountain Trail. The northern and eastern portions tend to be the most heavily infested, primarily by common dandelion, common plantain, and shepherd's purse. Control work was conducted during the afternoon while visitors were absent, and revisited over several days to ensure that all campsites were surveyed without infringing on the campers' privacy.



Figure 5. Dumpling Mountain is primarily covered in dense tundra

The June visit revealed dandelions in various stages of their phenology, as well as young plantain shoots. Several plantains were also found within the first 100 meters of the Dumpling Mountain Trail head. The campground was not revisited in July due to heavy visitor use. In August, the plantains were found in every stage of their phenology and new dandelion sprouts were scattered throughout the northern half of the campground. There was no sign of the previous years' shepherd's purse infestation, but a thriving native *Stellaria* was discovered on the Dumpling Mountain Trail. Positive identification is essential in discerning between native and invasive *Stellaria* and *Cerastium* in the area.

Employee Facilities

Housing and facilities for Brooks Lodge and Park Service employees are predominantly situated in the northern portion of the BCDA. NPS cabins are located along 'Park Avenue' between the ranger station and the campground. Brooks Lodge employees are housed in an area referred to as 'Tuckerville' to the west of Park Avenue. Common dandelion, common plantain, shepherd's purse and *Trifolium repens* (white clover) have all been reported in this area in previous years.

In June, dandelions were controlled in Tuckerville, around the Lodge maintenance building, and along the trail from Tuckerville to the Lodge. A few plantains were discovered around the Lodge maintenance building and on the northern side of the generator, though none appeared to have spread further into Tuckerville or down Park Avenue. In August, a few new dandelion rosettes were discovered between the yurt and the NPS bathhouse, and new plantains were found around the generator.

Visitor Center Area

The Visitor Center (VC) area includes the VC, the adjacent food and gear cache, pit toilet, picnic area, ranger station, and auditorium. Only a native *Stellaria* was noted along the western edge of the auditorium this year.

Cultural Site

The Brooks Camp cultural site has been of great concern in past seasons; however, with regular manual treatment and revegetation, the area has become an EPMT 'success story.' Accessed by a short trail leading from the auditorium, the site exhibits a prehistoric pit house, or *barabara*,



Figure 6. Native populations now dominate the lawn in front of the cultural site

demonstrating native Alaskan construction techniques from several thousand years ago. Maintained with brush cutting, the area immediately around the structure has had significant infestations of common dandelion with individuals spreading down the slope behind the interpretative sign, along the trail towards the auditorium, and behind the building on animal trails. Each year, the observed density of dandelions continues to decrease. Shepherd's purse has also been found at the site, though only dandelions were discovered and treated this season.

Dandelions were noted in all stages of their phenology in mid-June, including empty seed heads. They were scattered throughout the lawn in front of the structure and between the eastern edge of the building and the trail. There were also a few stray individuals across the trail behind the overlook sign, and along the animal trails on the north-western edge of the structure. In July, August and September a handful of young dandelions were found and manually removed.

Brooks Lodge

Most visitor activity is concentrated around Brooks Lodge, the primary guest service provider in the area. Brooks Lodge is open from June to mid-September and sees heavy visitation by float planes and boats throughout the season. Common dandelion, common plantain and shepherd's purse are prevalent around the buildings and along interconnecting trails. Control work was typically executed in the afternoon while most guests were out of their housing for the day.

Common dandelion was found throughout the lawns and paths of Brooks Lodge all season, though due to heavy mowing they were never in flower or seed. The heaviest infestations occurred between and behind the cabins of the marsh overlook, in the lawns around the bathhouse, and in the lawns next to the kitchen. A few plantains were found and removed around the fish freezing building in June and did not reoccur for the rest of the season. A patch of shepherd's purse was discovered on the slope of the fishing trail from the overlook to the marsh. The stand had already gone to seed in June and smaller individuals were scattered further down the trail. In July, individual shepherd's purse were found and removed around the entrance to the Trading Post. Large numbers of shepherd's purse were discovered on the western side of the trail leading to the 'corner' all season. *Arabidopsis lyrata* (Lyrate rockcress), a native look-alike to shepherd's purse, was scattered around and under cabins 22-24. Future EPMTs should be sure to study the morphology of these species in order to correctly identify native vs. non-native mustards.

Overall, common dandelion is the most pervasive invasive in the area and more time should be dedicated to manually treating individuals around the lodge in future seasons. The NPS might consider herbicide application around the Lodge, cultural site, and campground in future seasons, or have a volunteer crew in June or August to help with the manual control work.

Mouth of the Brooks River

The mouth of the Brooks River presents opportunities for fishing and wildlife viewing, and sees heavy traffic by employees and visitors accessing the south side of the BCDA. Boats and vehicles



Figure 7. M. Armstrong pulling shepherd's purse on the spit

used by Lodge and NPS staff are parked in the area, and construction vehicles, equipment, and materials come and go via the Spit Road, making this area a prime vector for the spread of invasives. Shepherd's purse can be found throughout the area all season long, with a few dandelions early in the summer.

Shepherd's purse had already completely infested the closed trail and had gone to seed in large stands from the bridge all the way to

the tip of the closed trail by mid-June. Smaller plants were found at the "Corner" and along the trail from the fish freezing building to the "Corner." Lyrate rockcress was interspersed with the shepherd's purse, so care was taken to differentiate before manually controlling. Shepherd's purse was also present along the spit road, on the spit itself, and in the parking area next to the lower platform. A few individual dandelions and *Polygonum aviculare* (Prostrate knotweed) were

discovered between the lower platform and the small parking lot directly behind, but the area was otherwise free of invasives. In August, the shepherd's purse on the closed trail had returned but in significantly smaller numbers, while the shepherd's purse on the spit had exploded in quantity and area. After 12 hours of manual treatment on the spit, less than 25% had been eradicated, some of which were standing dead and had already dropped seed, while others were new stands in flower or in seed. In September, the lower river experiences very high bear use so control work was minimal.

Due to heavy traffic by employees and visitors, this area should be a top priority for future EPMT crews. While shepherd's purse does not have a high invasiveness ranking, this area is a key vector and could be responsible for the spread of shepherd's purse down the VTTS road and into the valley itself; or across Naknek Lake to other more remote areas via boat. Shepherd's purse has already been found on the VTTS road and at the mouth of Margot Creek, and the infestation on the spit is the most likely source of these infestations.

Barge Landing and Beaver Pond

The new barge landing was built in the winter of 2014 in preparation for the construction of employee housing on the Lake Brooks side, and an elevated bridge across the mouth of the Brooks River. In addition to the beach where the barge lands, the area includes a large fenced-in parking lot where heavy equipment is stored, and a road from the equipment parking to the start of the VTTS road. This road also accesses the beaver pond and is primarily used by park maintenance staff. No invasives have been found in the area to date.

Brooks Falls Trail & Platform

Brooks Falls, perhaps the most iconic of Katmai's offerings, experiences extremely high visitor use in July while bears fish the falls, with use dropping off significantly during the rest of the season. Shepherd's purse can be seen underneath the platform, though access is restricted from June 15-August 15 due to bear management and safety. Individual common dandelions, *Phleum pretense*

(timothy grass) and *Ranunculus acris* (tall buttercup) have been reported on the Falls Trail in past seasons, though there was no evidence of any of these invasives this year.



Figure 8. Working below the falls platform is impossible for much of the season due to heavy bear activity

In mid-June, shepherd's purse was spotted below the platform and on the western edge of the island below the falls. In July, bears had trampled the original stands of shepherd's purse, and there was no evidence of them below the platform or on the island. In August, the EPMT mapped and controlled new stands of shepherd's purse below the platform. There was no evidence of new growth on the island, but the area was mapped to represent the infestation as it had been observed in June. Future

EPMTs should attempt to work below the platform before June 15 to control the shepherd's purse as early in the season as possible.

Lake Brooks Side

Infrastructure on the Lake Brooks side of the BCDA includes housing for NPS employees, and picnic and recreation areas for employees and visitors. Lake Brooks is also occasionally used as the drop off point for float planes that are unable to land on Naknek Lake. Common dandelion, common plantain and shepherd's purse have all been found around the structures and along the road in previous years.

This year, the residential and visitor areas were manually treated for shepherd's purse and common plantain; no common dandelions were found from previous infestations. Shepherd's purse was already in seed in June and common plantain was found in flower in August around NPS housing.

Mortuary Cove

Since the 1990's, Mortuary Cove has been used as a mooring area for park service boats. Located just north of Brooks Camp, the trail to the cove is accessed by following the beach to a flagged path. During a visit in June, the beach, trail, and cove were surveyed and no invasives were found. The trail is rarely traveled but should still be monitored at least once a year.

The Valley of Ten Thousand Smokes

The Valley of Ten Thousand Smokes (VTTS) is a unique geological feature of KATM and the main reason for the parks' formation. The VTTS is an ashen valley formed from the Katmai volcanic eruption of 1912, and today it serves mainly as a popular tourist attraction. The valley floor itself is almost devoid of vegetation, however, the road from Brooks Camp to the VTTS is a highly trafficked area and susceptible to invasion.



Figure 9. VTTS from the 3-Forks Visitor Center.



Figure 10. Mapping at the sewage disposal site.

Valley Road Administrative Area

The area south of the Brooks Lake Employee housing between mile markers 1 and 5 on the VTTSR includes two notable locations: the Valley Road Administrative Area (VRAA) and Squirrel Camp. The VRAA comprises the construction area on the Brooks Lake side of the VTTSR, and the maintenance building. Construction of new employee housing began in 2013 and is still underway, and in 2014 the EPMT surveyed and controlled infestations of shepherd's purse and pineappleweed (Anderson and Lindsey, 2014). The 2015 EPMT found and removed shepherd's purse at the construction site in September. Shepherd's purse was

also removed in July and September from the maintenance yard and the adjacent path to the Brooks Lake Cabins. Additional infestations of shepherd's purse were discovered and removed at small construction sites, turnoffs, and a sewage disposal pit between the housing construction site and mile marker 1.5. Due to the high level of disturbance in the VRAA, future EPMTs should continue to monitor the area for new infestations. The other location of concern within this survey area is Squirrel Camp: a small housing area used formerly by transient contractors located near the VTTSR 1 mile marker. Previous crews have controlled shepherd's purse and pineappleweed at the site. In July, the EPMT preformed manual treatment of an infestation of shepherd's purse centered on the campfire pit.

5-Mile Gravel Pit

The 5-mile gravel pit is the source for all fill material used in the BCDA and the VTTSR. It also serves as a hub of maintenance activity and traffic. Due to the constant movement of heavy vehicles between the pit and other areas harboring invasives, it is an area of special concern for the EPMT. Previous EPMTs have treated shepherd's purse, *Crepis tectorum* (narrowleaf hawksbeard), and *Vicia cracca* (bird vetch) at the pit (Frank and Woods, 2011). The 2015 EPMT visually inspected the pit in June and took GPS coordinates of infestations in July. One patch of shepherd's purse and a new infestation of common plantain were manually removed from near the fence. One sparse group of narrowleaf hawksbeard individuals were discovered and removed from near the entrance road. The entire perimeter was surveyed with no other invasive plants found. Given the high volume of disturbance and traffic through the gravel pit, it is recommended that the entire area, from the tree line to the VTTSR, continue to be surveyed each year.

Valley of Ten Thousand Smokes Road

The VTTSR begins at the lower platform at Brooks's camp and runs 23 miles to the 3-Forks Visitor Center. There is one-way traffic on the road including a daily bus bringing tourists to the VTTS. Along the route are several pull-offs and river crossings where staff and tourists are able to stop and walk around on the road. In previous years, EPMTs have confirmed localized infestations of pineappleweed and shepherd's purse beyond the 5-mile gravel pit. Additionally, the high ranking species bird vetch had been found at two locations (first river crossing and the 13.5 mile marker). These infestations were

inspected and chemically treated for several years. Fortunately, the 2015 EPMT surveyed the areas formerly occupied by bird vetch and found no evidence of new growth.



Figure 11. View of the VTTSR from near the 5-mile gravel pit.

The length of the VTTSR was surveyed on foot throughout the month of July. No invasives were found along the road between 3-Forks and the third river crossing. Several small patches of pineappleweed were found between the second and third river crossing, including one patch directly underneath the maintenance grader. These were removed because of their small size, isolation, and proximity to the VTTS. Within the same road segment, a *Cerastium* population was discovered. These were not treated due to a possible native look-alike, thus their taxonomic identity is still unclear. The road segments between the second river crossing and the 5-mile gravel pit harbored only pineappleweed infestations which were not treated. Popular stops along the road including the Research Bay and Kettle Pond overlooks, and the pit toilets were surveyed with no invasives found. While no highly ranked invasives were seen, the presence of pineappleweed under the tires of NPS equipment on the road illustrates the possibility of spreading unwanted plants via vehicle traffic.

Ukak Falls, Margot Falls, and Windy Creek Trails



Figure 12. Section of the Ukak Falls.

The main hiking trails leading away from the VTTSR have harbored only a couple of low ranking invasives (common plantain and annual bluegrass) in previous seasons. The 2015 EPMT surveyed the Margot Falls Trail and the Ukak Falls Trail in July, revealing no invasive plants. The Windy Creek Trail originates from the VTTSR 1 mile west of 3-Forks and is the main access point to the VTTS floor. 2015 EPMT members surveyed the trail several times during the season while hiking into the Valley, but did not discover any invasives. In August, a report of common plantain that had returned from a previous infestation was received

(Mike Fitz, KATM, Pers. Comm.). During the August survey, no common plantain individuals were found, and the rest of the trail remained invasive free.

Naknek Lake

North Arm

The North Arm makes up the largest portion of Naknek Lake, connecting Lake Camp to Brooks Camp, the Bay of Islands, and several creeks; all of which are used for fishing or camping due to the ease of access from King Salmon by boat. Idavain Creek and Dumpling Creek empty into the North Arm, the mouths of which are occasionally visited for fishing. Fure's Cabin, a public use cabin with a portage trail that is part of what is known as the 'Savonoski Loop,' is also located in the North Arm.

Lake Camp

Lake Camp is located on the Naknek River just south of Naknek Lake. Many NPS staff, park visitors, and local fishermen use Lake Camp for fishing, boat storage, and travel. Additionally, NPS heavy equipment travels through Lake Camp on its way to Brooks Camp. These factors make Lake Camp a major hub of movement through the park. As a consequence, Lake Camp is a high risk vector for invasive plants into the park. Previous EPMTs have documented infestations of common dandelion, sheep sorrel, pineappleweed, shepherd's purse, and *Leontodon autumnalis* (fall dandelion)

from the Lake Camp sign to the edge of the river. Chemical treatment of these species proved successful and has reduced the total abundance of these populations over the last several years. The 2015 EPMT visited Lake Camp once a month in June, July, August, and September. In June, all surveyed sheep sorrel individuals were chemically treated. In July and August, manual treatment of several common dandelion and fall dandelion individuals was conducted. The last visit in September concluded with the manual removal of the remaining fall dandelion and prostrate knotweed stands located near the barge landing and the Lake Camp sign. No shepherd's purse was found at Lake Camp this year.

Bay of Islands

An extensive survey of the Bay of Islands was conducted by boat, revealing no invasives. Double Beach and Thin Beach were surveyed during a law enforcement patrol after July 4, and known campsites and fishing locations were visited in mid-July. Landings were made whenever conditions were considered safe, otherwise visual surveys were conducted from the boat deck. Surveys included Coke Island, Burnt Island, Prince Island, La Gorce Point, several unnamed beaches and fishing points, and several unnamed marshes. Continued monitoring of the area should be a priority due to its ease of access from Lake Camp and Brooks Camp, both of which are sites of known infestations.



Figure 13. Surveying the Bay of Islands with the NPS Palayaq

Fure's Cabin

Located within the Bay of Islands, Fure's Cabin is a restored public use cabin surrounded by a south facing grass field and backed by a portage trail leading to Grosvenor Lake. It is both a popular camping location and a portion of the Savonoski Loop; a kayak/canoe route that begins at Brooks Camp. The field is brush cut and home to a large common dandelion infestation which has been



Figure 14. Fure's Cabin

chemically treated with Milestone each year since 2011. Previous teams have also found shepherd's purse and pineappleweed around the fire pit, and *Cerastium fontanum* (mouse-ear chickweed) on the portage trail.

The first visit to Fure's in early June revealed a healthy common dandelion population in various stages of its phenology. June dandelions were treated with Milestone herbicide, applied after removing flower and seed heads. A revisit in August found many more dandelions present, all of which were manually treated. Dandelions appeared to have spread further down the portage trail, while none of the previous infestation of mouse-ear chickweed was observed.

Idavain and Dumpling Creeks

Idavain Creek is a popular fishing destination in Naknek Lake. Anglers commonly arrive by boat or floatplane on the beach and walk the bear trails running along the creek banks. Previous EPMTs have found three pineappleweed individuals, but none were found the following year and the 2015 July visit revealed no invasives in the area. Similarly, the mouth and beach around Dumpling Creek were found to be invasive free.

Iliuk Arm

The Iliuk Arm begins at the terminal moraine adjacent to Brooks Camp and extends to the mouth of the Savonoski River. Margot Creek also empties into the Iliuk Arm and is a popular fishing destination with visitors arriving by boat or floatplane. In addition, Spruce Island is a commonly visited location as the terminus of the Savonoski Loop. Research Bay contains a set of islands occasionally visited for camping, and a beach on the eastern portion of the lake was used in previous seasons as a base camp for an educational program which was accessed by boat. This years' team spent a day in July surveying all of these locations and found the first documented case of shepherd's purse at the mouth of Margot Creek. Pineappleweed and a few shepherd's purse individuals were discovered and removed on the western edge of the eastern most gravel bar. The survey covered all of the gravel bars, trails up either side of the creek, and the western beach. A comprehensive survey of the eastern beach was cut short by bear activity. Native dandelions were noted on one of the beaches on an island in Research Bay; no other invasives were found at any of the sites visited in the Iliuk Arm.

Lake Brooks

In July, surveys were conducted for the first time on several sites on Lake Brooks including Headwaters, Missy's Island, and the mouths of several unnamed creeks. Though the EPMT could not locate a commonly used campsite on Missy's Island, a survey was conducted on a beach often accessed for recreation. Headwaters and the unnamed creeks are occasionally visited for recreation or fishing;

however no invasives were found at any of these sites.



Figure 15. A bear pushed the EPMT off Missy's Island

Grosvenor Lake

Grosvenor Lake and Grosvenor Lodge were surveyed for the first time in 2013. Species previously discovered in these surveys include common dandelion, annual bluegrass, shepherd's purse, and pineappleweed (Landry and Voznitza, 2014). The bulk of these sightings occurred at Grosvenor Lodge. The 2015 EPMT surveyed a previously unvisited section of the northern edge of Grosvenor Lake. The mouths and nearby beach areas of two unnamed creeks were surveyed in mid-September with no invasive species discovered. Inclement weather prevented any survey or control work at sites near Grosvenor Lodge. With known infestations of several invasives at Grosvenor Lodge, it would be beneficial for future EPMTs to reach out to the lodge owners in order to mitigate future spread of invasives to other areas of the lake.

Hammersly Lake

Hammersly Lake forms the headwaters of American Creek and lies between Grosvenor Lake and Nonvianuk Lake. The lake is visited primarily by river rafting groups and fishermen. This site was visited by the EPMT for the first time this year. The survey was conducted in late June; the only sign of human disturbance was a short fisherman's trail near the start of American Creek. Three areas of the lake were surveyed: the northern shore, the eastern shore near the mouth of a small creek, and the first 100 meters of American Creek. While the area boasted an excellent diversity of native plants, no invasive plants were recorded. A brief survey of the lake bottom at several shallow locations did not reveal the presence of *Elodea*.

Outer Coast

Identifying and surveying areas of former use and disturbance on the Katmai coast is of primary importance due to a long history of anthropogenic use including villages, canneries, farms, and mining operations. Current use includes bear viewing at



Figure 16. M. Armstrong preps the Trimble for a survey of Mink Island

Geographic Harbor, Hidden Harbor, and Hallo Bay, NPS ranger cabins at Amalik and Swikshak Bays, private lodges at Kaguyak and Kukak Bays, and visitation by NPS staff to archeological sites along the coast. As one of the most logistically challenging places to reach in the park, the outer coast has received sporadic surveys in the past several years.

Geographic Harbor and Amalik Bay

Geographic Harbor and Amalik Bay have supported much anthropogenic use; everything from native sites and mining operations to a fox farm and trapping cabin. While this history attracts many archaeologists to the area, Geographic Harbor draws many more bear viewers resulting in increased float plane and boat traffic. In 2014, KATM launched a pilot program stationing rangers at the patrol cabin for part of the summer to track visitor use and make contact with operators working in the area. The expansion of this program allowed the 2015 EPMT to visit the cabin and conduct extensive survey work within the harbor, bay, and on surrounding islands in July. No invasives were found, though native *Chrysanthemum arcticum* (arctic daisies) were noted around the cabin and on Mink Island. Surveyed areas included the “photographer’s island” and surrounding land, the beach adjacent to the island containing an old cabin site, an expanse of beach that was home to a pumicite mine, archaeological sites on Takli, Little Takli, and Mink Islands, and the tidal flats in the immediate vicinity of the patrol cabin. Subsequent surveys should be conducted every few years to ensure the area remains invasive free, though annual visits are unnecessary at this time.

Hallo Bay

Due to its reputation for supporting massive quantities of bears grazing the sedge meadows and clamming the tidal flats, Hallo Bay has a long history of visitor use related to bear viewing. Although reports seem to indicate a decline in the number of bears in the area, visitation has grown exponentially, with daily flights from Kodiak and Homer dropping off long term campers, day trippers, or even picnic flights (French, 2007). Visitors

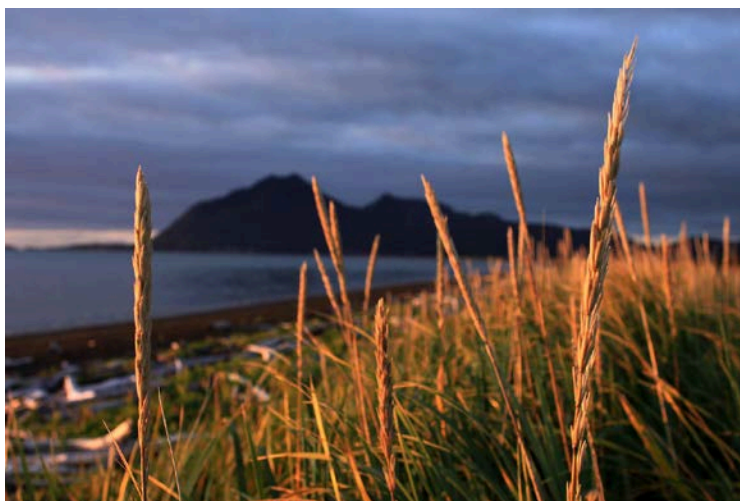


Figure 17. Hallo Bay is famous for bear activity related to its sedge meadows, clamming, and fishing

also arrive at Hallo Bay by boat from lodges in Kaguyak Bay for overnight or day trips. NPS law enforcement regularly visits the area and has a campsite in South Hallo. In 2014, KATM launched a pilot program stationing interpretive rangers at a campsite in North Hallo. As with Amalik, this program was expanded in 2015, allowing the EPMT to conduct extensive surveys of the area using the ranger campsite as base. During a brief day trip at the end of June, a common dandelion and common plantain were found in the middle of the ranger campsite; most likely transported on gear brought in by NPS staff at the beginning of the season. Pineappleweed was found during a long term visit in early September, also in the middle of the campsite. Areas where

extensive surveys were conducted during this time included the beach from North to South Hallo, trails in South Hallo connecting float plane drop off points and known campsites, trails through the North and South Hallo meadows, and trails along Middle Creek where the most bear viewing occurs. No invasives were found outside of the interpretive ranger campsite.

Swikshak Bay

Swikshak Bay's recent history includes a canning operation run by the Kukak Cannery, the remnants of which were destroyed in 1972 by KATM personnel. The last comprehensive survey of the Bay was in 2005. Incidental trips to the area have thus far not documented any invasive plants. The 2015 EPMT was able to visit the patrol cabin in September with enough time to survey trails in the immediate vicinity of the cabin and beach. No invasive plants were identified.

Katmai National Preserve

Nonvianuk Cabin and River

The Nonvianuk Ranger Cabin is located near the start of the Nonvianuk River on Nonvianuk Lake. It is used primarily by NPS law enforcement (LE) officers and features several trails, campsites, and boat launches. Past EPMTs have recorded and performed manual and chemical treatments of sizeable populations of common dandelion and common plantain near the campsite and boat launch on river left. This year, the EPMT visited the area in early



Figure 18. Start of the Nonvianuk River.

August. Earlier attempts to survey the area and conduct chemical treatment were thwarted by weather. Surveys of the area immediately around the cabin as well as the foot paths leading away from the cabin revealed no invasives. The boat launch, float plane landing zone, and campsite on river left upstream from the cabin was found to harbor well known infestations of common dandelion and common plantain which were manually controlled. Additionally, several common dandelion individuals were found and removed for the first time in a small area on river right, across from the campsite. Future crews should prioritize chemical treatment at Nonvianuk Cabin to prevent the spread of invasives across the river and downstream of the cabin. Previous EPMTs have noted several *Taraxacum* specimens that appeared to be hybrids between common dandelion and its native congener *Taraxacum ceratophorum* (horned dandelion). This year's EPMT documented several *Taraxacum* individuals with superficial intermediate morphology. However, without molecular analysis these cannot be confidently confirmed as hybrids (Brock, 2004).

The full length of the Nonvianuk River beyond the Ranger Cabin was surveyed by boat in 2015. Surveys of the shoreline occurred on both sides of the river at campsites, popular fishing locations, and areas visited by the 2013 EPMT (Landry and Voznitza, 2014). Private inholdings were surveyed from the boat or by wading in the river near the shore. The Royal Wolf Lodge, located 0.25 miles from the Ranger Cabin, harbored pineappleweed along the road between its boat launch and main buildings. No control work was done since this is private property.

Moraine Creek, Funnel Creek, Twin Lakes, Crosswind and Mirror Lakes



Figure 19. Landing area of Crosswinds Lake.

The areas of the Preserve most visited include Moraine and Funnel Creeks as well as several small lakes accommodating float plane traffic. The majority of these visitors are fishermen and bear viewers and the most heavily utilized lake is Crosswind Lake. Past EPMTs have only found small isolated patches of annual bluegrass in the area. In August, the 2015 EPMT surveyed the campsites around Crosswind Lake and discovered no invasives. Moraine Creek was surveyed from the confluence of Moraine and Funnel Creeks to Pot Lake 4 miles west of Crosswind Lake where

pick-ups and drop-offs commonly occur. No invasives were discovered. Additionally, the EPMT surveyed the entire length of Funnel Creek, Twin Lakes, and the western end of Mirror Lake. No invasive plants were found at any of these sites.

Kukaklek Lake

Kukaklek Lake forms the headwaters of the Alagnak River and is the terminus of Moraine and Little Ku Creeks. The lake is utilized most by fishermen and bears capitalizing on the salmon run. While the eastern end of the lake has been visited by previous EPMT crews, the western side has never been surveyed for invasive plants. In August, the EPMT surveyed the island immediately north of Little Ku Creek (referred to as Little Ku Island), and the mouth of Little Ku Creek. No invasive plants were identified at either of these locations. A brief survey was conducted at a small sand airstrip 0.5 miles from the mouth of Moraine Creek on the eastern end of Kukaklek Lake. While a wide range of native tundra flora was recorded, no invasive plants were found.

Alagnak Wild River

The Alagnak Wild River (ALAG) is a separate NPS park unit co-managed by KATM. The river flows from Kukaklek Lake to the Kvichak River; approximately 69 miles of which within the park. The NPS does not maintain any public facilities along the river, and there are many private inholdings including private fishing lodges and native corporations. Before the 2015 season, no EPMT crew had surveyed in ALAG or traveled past the confluence of the Nonvianuk and Alagnak Rivers. The 2015 EPMT conducted a survey of the Alagnak River in early August; starting from the Nonvianuk Ranger Cabin and ending at the ALAG western boundary. Within ALAG, surveying started at the rapids located 6 miles from the confluence. Surveying was conducted by boat with onshore stops at locations with signs of human



Figure 20. NPS Biotech R. Peterson looking at the Alagnak Confluence campsite.

disturbance, known campsites, or popular fishing locations. Survey locations were situated on both sides of the river and were spaced at regular intervals. All private inholdings with visible signs of disturbance (structures, roads, campsites) were inspected from the boat or by wading near the shore.

Invasive plants were confirmed at only one location inside ALAG. The campsite at the confluence had a dense infestation of both common dandelion and pineappleweed. Control work could not be conducted because the site was situated on a private inholding. Infestations on other large private lodges inside ALAG were not confirmed but seem likely due to the extent of disturbance from large scale construction. While no invasives were found on park managed lands in ALAG, it would be prudent for future EPMT's to gain permission from these private landholders to survey on their property.

Aniakchak National Monument & Preserve

Aniakchak National Monument & Preserve (ANIA) is a remote, undeveloped, and infrequently visited NPS unit on the Alaska Peninsula located approximately 130 miles south of KATM. Despite its distance from the park, KATM assumes administrative duties for ANIA. Surveys performed in 2010 by the AKNHP revealed common dandelion growing along the river in undisturbed areas; an uncommon habit for dandelions in this region (Shepherd and Bartley, 2010). The only other survey in the area was conducted in 2012 and included visits to landing strips at Lava Creek Cabin, Klutsch's Cinder Strip, Cinder River, and Packer's Cabin. No invasives were found, although native dandelions and a nonnative chive—not considered invasive—was noted near Packer's Cabin. In 2015, the EPMT was able to visit Amber Bay and found no invasives.

Bristol Bay Borough

Bristol Bay Borough includes the towns of King Salmon, Naknek, and South Naknek. Most visitors to KATM travel through King Salmon, and every year thousands of non-local fishermen and cannery workers travel from King Salmon to Naknek, making King Salmon a high risk vector for many non-native invasive species.

NPS Administered Properties

NPS administered properties in King Salmon include the NPS HQ, NPS Dorm, marina building, float plane dock, maintenance yard, and areas of FAA housing. Similar to previous years, the 2015 EPMT found several common invasives at most NPS properties including: common dandelion, pineappleweed, shepherd's purse, common plantain, prostrate knotweed, and sheep sorrel. Inventory mapping of some of the larger infestations was performed at the NPS Dorm, NPS HQ, and at FAA Housing; however no control work was done at these sites. Inventory mapping of high risk species at FAA Housing and the NPS HQ, such as *Bromus inermis* (smooth brome),



Figure 21. Volunteer A. Hutchinson removing *R. repens* flower head from the Marina Building.

Trifolium spp., *Caragana arborescens* (Siberian peashrub), *Leucanthemum vulgare* (oxeye daisy), *Sorbus acuparia* (European mountain ash), fall dandelion, and *Prunus padus* (European bird cherry), was also conducted. Manual treatment on NPS King Salmon property was executed only at the marina building, NPS float plane dock, and the Maintenance Yard; areas that could serve as vectors for invasive species' access to the rest of the park.

At the marina building and float plane dock, common dandelion, shepherd's purse, common plantain, and sheep sorrel were removed in June and July. In addition to these species, a large infestation of *Ranunculus repens* (creeping buttercup) was discovered growing along the bank of the Naknek River at both locations. This rhizomatous plant has the ability to spread to previously unoccupied areas very rapidly and is of concern to the EPMT. Manual removal of creeping buttercup flowers, seeds, and large amounts of biomass was conducted with the goal of reducing its reproductive potential. The 2015 EPMT recommend chemical treatment of all creeping buttercup on NPS property. Surveys of the NPS Maintenance Yard in June and July revealed the presence of only one concerning invasive species, narrowleaf hawksbeard. A small number of individuals were confined to the north and east sides of the yard. These were manually removed and the yard was continually monitored for any recurrences.



Figure 22. *R. repens* growing near the Marina Building.

Non-NPS Administered Properties

A major focal point for this year's EPMT was FWS owned land in King Salmon. Surveys in June and July revealed dense infestations of several common invasives (common dandelion, common plantain, and shepherd's purse), and a few uncommon ones (*Chenopodium* and *Papaver*) near FWS HQ. More concerning was a large infestation of narrowleaf hawksbeard and creeping buttercup near the FWS float plane dock. Within each population, total ground cover ranged from 50%-75%. In coordination with FWS staff, manual control of narrowleaf hawksbeard and creeping buttercup was performed. For creeping buttercup, removal of plant reproductive parts was deemed sufficient to limit its invasive potential. Based on this management action, it seems crucial to form an integrated



Figure 23. *V. cracca* found growing along the Alaska Peninsula Highway.

partnership with the FWS in order to prevent the spread of invasive plants on FWS lands, and to limit their spread onto NPS lands from FWS vectors.

Control work in King Salmon was only conducted on government owned lands. However, several notable invasives were discovered and mapped on municipal properties. Creeping buttercup was found for the first time off government land at the City Dock and along "Float Plane Row." Known infestations of narrowleaf hawksbeard and oxeye daisy near the King Ko Inn have grown in size and percent cover from previous years' surveys. *Hieracium*

umbellatum (narrowleaf hawksweed) was again found growing along the King Salmon Airport fence. An infestation of fall dandelion starting from the corner of Sockeye and Coho Roads extended for hundreds of meters and had a total ground cover of greater than 90% at some places. Along the Alaska Peninsula Highway, a small patch of bird vetch was found. All of these occurrences have the potential to spread to nearby park lands, thus, future consideration of possible management actions for each instance would be advisable.

Education and Outreach

Community outreach and education is a key component of invasive plant management. Since humans are the most common vector for invasive plant movement, effective prevention includes public education about invasives; the threats they pose to the environment and economy, how they disperse and propagate, and what people can do to limit their spread. The 2015 EPMT contributed to three public education programs, produced several new outreach products for both the public and NPS staff, created social media products, and were featured on a local public radio station.

The EPMT hosted an invasive plant children's program at the KSVC. The objectives of this program included: understanding the threat posed by invasive species to native communities; understanding how invasive species become a problem via human-mediated spread and how to prevent it; identifying a few of the most common plant invaders, and learning how to successfully remove them. A group of 15 local children and their parents participated in the program.

They were shown live specimens of invasive plants, engaged in a scavenger hunt using plant characteristics, and learned how to use a plant press to preserve their finds. The EPMT also manned a table at Fishtival, a celebration at the conclusion of the salmon season in Naknek, with other NPS staff in order to answer questions about invasive plants asked by the public. Additionally, the EPMT offered logistical support to the annual FWS September Science Camp for high school students. FWS staff were given information about the characteristics of the most common invasive plants in the area. A data sheet was prepared so students could record GPS points and attribute data on invasive plant infestations found within the Becharof Wildlife Refuge. Through the partnership formed between the NPS EPMT and the FWS, the science camp students were able to learn about invasive plant ecology, identification, GPS technology, and citizen science projects.

Outreach materials included an update to the basic invasive plant brochure that is used at the KSVC, the Brooks Camp VC, and the 3-Forks VC. The brochure was updated with new photos, information and design, and disseminated to all KATM visitor centers: Fishtival and the boot brush at the NPS dock. A new *Elodea* sheet was created for inclusion in next years' commercial services handbook with basic information about the threat of *Elodea* and its discovery in Lake Hood: a hub for float plane traffic around Alaska and to KATM. New materials for both the public and KATM staff



Figure 24. NPS tabling event during Fishtival.

include a template to be used for the generation of a series of information sheets about the most common invasive plants in KATM. This template can be modified by future EPMTs as information about the park's most prevalent invasives change, or when additional species need to be added. A very basic document highlighting KATM native plants was created to serve as a resource for staff who are interested in learning more about the park's flora. Begun primarily as a record of some uncommon species and to aid in differentiating between native and invasive look-alikes, future EPMTs can add plants as they identify them in the field. Additionally, the segment of the Natural Resources Newsletter dedicated to the EPMT was updated, and social media products were created for the KATM facebook page and blog. Lastly, information about the EPMT was featured on KDLG, a local public radio station.

Prevention and Restoration

The most efficient and cost-effective form of management for invasive plants is prevention. Identifying ways invasives spread into the park and showing initiative in deterring their invasion is paramount in prevention strategies. Previous EPMT crews inspected heavy machinery and equipment bound for construction at Brooks Camp for evidence of invasive plants. Crews have also engaged in restoration efforts in order to mitigate the probability of invasive plant spread to newly disturbed construction sites. Re-planting of native genera at sites of recent disturbance will greatly reduce the ability of invasive plants to occupy these areas. At Brooks Camp, ongoing construction has necessitated the creation of a native plant restoration plan. The 2011 and 2012 EPMT created a document suggesting different restoration techniques for different disturbance regimes (Connealy and Parker, 2013). The 2013 EPMT began revegetation efforts after the end of a major construction project at Brooks Camp by sowing native seeds and transplanting native vegetation to recently cleared sites. The 2013 and 2014 crews created a seed bank with which to store native seeds for revegetation work (Anderson and Lindsey, 2014), and the 2015 EPMT continued this effort by expanding the size of the seed bank. In September, seeds from *Calamagrostis canadensis* (blue-joint grass), *Achillea millefolium* (yarrow), *Epilobium angustifolium* (fireweed), and *Geum macrophyllum* (large-leaf avens) were collected from the field, dried for several days, cleaned, and then bagged and stored in the Duplex freezer. These species were chosen for their excellent colonizing ability following disturbance. As major construction projects at Brooks Camp are expected to begin in the near future, it is imperative that future EPMTs enlarge the size of the seed bank, and develop a viable mitigation and restoration plan.

Disposal Methods

Past KATM EPMTs have employed various methods of invasive plant disposal including sterilizing plants in an oven, burying plants at a local dump, and incinerating plants in burn barrels fueled by gasoline or diesel. These methods proved to be inefficient and prompted the search for alternative approaches. Since 2013, all plant materials have been destroyed using the Brooks Camp incinerator. This method allows for the complete disposal and sterilization of all plant parts. The 2015 EPMT incinerated all plant material collected at Brooks Camp immediately after harvesting. Weeds collected elsewhere were temporarily stored in the marina building and shipped to Brooks Camp for incineration. The 2015 crew recommends that this process be continued by future EPMT crews. To ensure complete disposal of all plant parts, future crews should remove as much soil as possible from

the roots of plants and allow the plants to dry in order for them to combust more easily. In the event that the Brooks Camp incinerator becomes unavailable for EPMT use, other alternatives have been suggested for plant disposal (see Anderson and Lindsey, 2014).

Phenology

Plant phenology (timing of flowering, pollen release, senescence, etc.) is an important consideration for invasive plant management. Information about when invaders reproduce in conjunction with knowledge about their reproductive, physiological and life history biology is critical when planning to control invasive populations. We present data on observed flowering and seeding times of 13 common and notable invasives from the 2015 season (Table 3). Flowering and seeding phenology is a plastic response to local environmental conditions, thus the timing of these events will vary from year to year based on changes in local conditions. However, this data should highlight general trends for future EPMTs. Most importantly, note that species such as common dandelion, sheep sorrel, creeping buttercup, and shepherd's purse tend to flower early in the season (May, early June), while other common invasives flower later in the season (late June, July).

Table 3. Approximate date of first flower and seed set for common invasive plants in King Salmon and Brooks Camp during the 2015 season (NA=Plants have not been observed setting seed).

Taxon	Common Name	Approximate Date of First Flower	Approximate Date of First Seed Set
<i>Capsella bursa-pastoris</i>	Shepherd's Purse	June 8	Mid-June
<i>Crepis tectorum</i>	Narrowleaf Hawksbeard	June 22	July 20
<i>Hieracium umbellatum</i>	Narrowleaf Hawksweed	July 27	August 4
<i>Leontodon autumnalis</i>	Fall Dandelion	July 1	Mid-July
<i>Leucanthemum vulgare</i>	Oxeye Daisy	June 5	Mid-July
<i>Matricaria discoidea</i>	Pineappleweed	June 15	Mid-August
<i>Plantago major</i>	Common Plantain	June 20	July 18
<i>Polygonum aviculare</i>	Prostrate Knotweed	June 24	Late-August
<i>Ranunculus repens</i>	Creeping Buttercup	June 1	July 11
<i>Rumex acetosella</i>	Sheep Sorrel	June 1	June 8
<i>Stellaria media</i>	Common Chickweed	June 8	NA
<i>Taraxacum officinale</i> ssp. <i>officinale</i>	Common Dandelion	May 6	May 12
<i>Vicia cracca</i>	Bird Vetch	June 28	Mid-August

Recommendations for the NPS and 2016 Field Season

Consider a plan to allow EPMTs and applicators to spray chemical herbicides inside the BCDA. Specifically, this plan should consider chemical treatment of shepherd's purse on the spit and closed trail, and common dandelion and common plantain at the cultural site and campground. If chemical treatment in the BCDA is not an option, recruit volunteers to help with manual treatment in June and August when there are fewer bears and visitors, and large infestations.

Form a partnership or reciprocal agreement between NPS and FWS that will allow EPMTs to chemically treat infestations with FWS staff on FWS lands. Specifically, the creeping buttercup, common dandelion, shepherd's purse, narrowleaf hawksbeard, and sheep sorrel infestations near the FWS float plane dock and boat storage.

Conduct chemical treatment of common dandelion, sheep sorrel, and fall dandelion at Lake Camp, Fure's Cabin, Grosvenor Lodge, and Nonvianuk Cabin as early in the season as possible. Consider reapplication of herbicide at the same sites later in the season when new plants germinate, and to catch any plants that were missed in the first round of application.

Construct a solid lesson plan for VC children's programs and the FWS high school science camp. Inform float plane pilots, angler CUA's, and others who may be exposed to *Elodea* about the dangers of aquatic weed transport and recommended preventative measures.

Educate staff, especially maintenance staff and back country wilderness rangers, on how to properly prevent invasive plant spread via heavy machinery and back country gear.

Continue to update all outreach materials with current and relevant information on invasives within KATM, native identification, and aquatic transport of *Elodea*.

Open a dialogue with the Air Force in order to gain permission to remove highly ranked invasives from around the NPS HQ.

Open a dialogue with the Alaska State Department of Transportation to gain permission to remove highly ranked invasive species from the Alaska Peninsula Highway (i.e. bird vetch).

Develop a long-term EPMT plan that revisits sites that do not need annual surveys on a rotating basis. For example, walking the VTTSR or large surveys of "none found" areas could happen every few years while areas of known infestations should be revisited each year.

Form a native plant restoration plan for disturbed areas following the bridge construction at Brooks Camp.

Contact private landowners on the Alagnak River as well as Grosvenor Lodge and other private inholdings to gain permission for invasive plant removal on their properties.

Recommend that at least one member of the KATM crew in future years should have a herbicide applicators license.

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