



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

2016 Summary Report

Natural Resource Report NPS/KATM/NRR—2016/1349





ON THIS PAGE

Photograph of the resource management boat, the Palayaq, in the Bay of Islands. Photo by C. DeVries.

ON THE COVER

Photograph of C. DeVries pulling common plantains (*Plantago major*) on Dumpling Mountain. Photo by N. Zampieri.

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

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Natural Resource Report NPS/KATM/NRR—2016/1349

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Data in this report were collected and analyzed using methods based on established protocols and were analyzed and interpreted within the guidelines of the protocols. In addition, this report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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Abstract

2016 was the seventh season that the Alaska Exotic Plant Management Team (EPMT) protocol was followed to survey and control invasive plants in Katmai National Park & Preserve (KATM). Field work was focused on surveying new remote sites, controlling invasive plants in high traffic areas, and forming partnerships with lodges within KATM that will allow control work to be carried out on their private inholdings. New sites surveyed this year included American Creek and Battle River, along with expansions to previous surveys in many locations. A partnership with local Fish and Wildlife Service (FWS) also allowed the EPMT to assist with an invasive plant problem in the Alaska Peninsula National Wildlife Refuge. Manual and chemical treatments were carried out to control larger infestations at Brooks Camp, Fure's Cabin, Nonvianuk Ranger Cabin, Grosvenor Lodge, and Battle River Wilderness Retreat. *Taraxacum officinale* ssp. *officinale* (common dandelion) infestations at Brooks Camp, Fure's Cabin, Nonvianuk Ranger Cabin and Battle River Wilderness Retreat were treated with Milestone herbicide. Manual treatment remains the standard for all other invasive plant species in the park. Water samples were collected this year to test for the presence of the aquatic invasive *Elodea* through environmental DNA (eDNA) analysis in high use bodies of water in the park. Katmai National Park remains one of the most pristine areas in the National Park system, with healthy, intact ecosystems and very few invasive plant species. Continued monitoring, control work, education, and outreach are essential to the continued preservation of this wild, beautiful park.



Figure 1. N. Zampieri removes shepherd's purse at Brooks Camp.

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We would like to thank Carissa Turner for her support and guidance this field season. Special thanks to Bob Peterson for guiding us into the backcountry and ensuring we made it back out alive. Thank you to Craig Ricks for flying us out to remote areas and making sure it was done safely. We would like to thank our EPMT regional staff Chris Overbaugh and Peter Frank for their knowledge, guidance, and patience with training, answering questions, analyzing data, and proofreading. Finally, we would like to thank the SCA and AmeriCorps for providing us with this wonderful opportunity to explore, learn, and do what we love in such an amazing location.

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

DNR Department of Natural Resources

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

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 spans over four million acres of scenic, wild land at the base of the Alaska Peninsula. First established as a National Monument in 1918, the park was created to protect the natural volcanic wonder known as the Valley of Ten Thousand Smokes (VTTs). Since its establishment, the park has expanded and it now draws in visitors from around the globe with its dense populations of brown bears and world class fishing. KATM boasts an extremely wide variety of habitat types, ranging from coastal meadows to alpine tundra to rich freshwater river systems. The Alagnak Wild River (ALAG) and Aniakchak National Monument & Preserve (ANIA) are nearby national park units that are also managed by KATM.



Figure 2. A map of Katmai National Park and Preserve

Although Katmai is one of the larger national park units in Alaska, its remote location makes it one of the least visited. The most highly visited area in the park is Brooks Camp, which draws in visitors with excellent opportunities for bear viewing and some of the best fishing in the world. Brooks Camp

is also where the 23 mile road to access the Valley of Ten Thousand Smokes originates. Other highly visited areas of the park include Hallo Bay and Amalik Bay on the coast, Crosswinds Lake and Moraine Creek in the preserve, and various fishing lodges located on private inholdings.

Invasive Plant Ecology and Management

The introduction of non-native invasive plants to an ecosystem can be damaging in a number of ways. Invasive plants are characterized as plants that become established in areas where they have not existed previously and demonstrate an ability to outcompete native species (Mack et al. 2000). These plants often have the unique ability to survive in a variety of different conditions, have high rates of seed production, or possess other advantageous qualities (Thompson 1991). Reduced biodiversity of native plants, negative impacts on animal populations, alteration of soil chemistry, and negative economic impacts can all result from the establishment of invasive species (Vilà et al. 2011). As many as 42% of species on the Threatened or Endangered Species List are vulnerable primarily due to the presence of invasive species (Pimentel et al. 2005).

Economic impacts due to establishment of invasive plants are most often discussed in regards to policy and management decisions because they are the most quantifiable. Invasive plants can reduce agricultural yields and have negative impacts on grazing herds (Vilà et al. 2011). The presence of invasive species in the US is thought to be responsible for up to \$120 billion annually in damages (Pimentel et al. 2005). Invasive species can also have a substantial impact on the aesthetic appeal of an area, which is especially important in areas like national parks. Control efforts are labor intensive and costly, including manual, mechanical, chemical and biological control methods.

Katmai EPMT Survey and Management History

The NPS established the EPMT in 2000 to address the growing issue of invasive plants in parks. The goal of the EPMT is to establish small regional teams dedicated to early detection and removal of invasive species in their areas. There are currently 17 EPMT units located throughout the country. The KATM EPMT is part of the Alaska EPMT (AKEPMT).



Figure 3. A common dandelion that has been sprayed with herbicide containing blue dye.

Global Positioning Data (GPS) depicting the distribution of invasive species in KATM was first collected in 2000 by the US Geological Survey (USGS). In 2005, data was collected by the EPMT to contribute to three invasive databases: the Alaska EPMT geodatabase, Alien Plant Control and Monitoring (APCAM), and the Alaska Exotic Plants Information Clearinghouse (AKEPIC). AKEPIC is an extensive database that receives geospatial information on invasive plants from multiple agencies throughout Alaska and the Yukon. From 2005 to 2009, invasive plant surveys and control work have been carried out intermittently in high traffic areas by volunteers, NPS staff, Tribal Civilian Corps (TCC), and Southeast Alaska Guidance Association (SAGA) crews (Bauder and Heys, 2005; Rapp, 2009). Starting in 2010, KATM has had two Student Conservation Association (SCA) interns to perform surveys and control work, and efforts have expanded to monitoring much more remote areas of the park, including the preserve and the outer coast.

The most effective way to control invasive species is to prevent their introduction in the first place, which has been a priority for the EPMT in recent years. In 2011, the KATM EPMT installed boot brushes and informative signs at entry points to the park and initiated a protocol for the inspection of construction vehicles that would enter the park. A revegetation manual has also been produced by the EPMT that details procedures to be followed in disturbed areas to restore them before invasive species have the opportunity to establish. Most years the EPMT hosts invasive species programs for kids at the King Salmon Visitor Center (KSVC), and assists with the U.S. Fish and Wildlife Service (FWS) high school science camp in September. When available, the EPMT provide information on invasive species at Fishtival, the annual community celebration of the end of salmon season in Naknek.

The goal of the 2016 EPMT crew was to provide the NPS with information and recommendations to continue improving invasive species management within KATM. 2016 is the first year that two members of the KATM EPMT became certified pesticide applicators, which greatly increased the amount of control work that could be accomplished within the season. The 2016 EPMT also sought to make connections with the many lodges on private inholdings within the park, which led to control efforts that will help prevent the spread of invasive plants to more remote areas of the park. Backcountry inventory in remote locations remained a priority this season and trips to multiple previously unsurveyed areas were carried out. Manual control of invasive plants continued to be a main focus of the EPMT across the park. In 2015, visual surveys were conducted for aquatic invasive plants, and this season the EPMT were able to collect water samples from twelve high use lakes to be sent in for eDNA testing to check for presence of *Elodea* (Figure 4). Additionally, outreach materials on *Elodea* and terrestrial invasive plants were produced and distributed by the 2016 EPMT.



Figure 4. C. DeVries collects a water sample from Pike Lake to be tested for Elodea DNA.

Methods

In 2016, field work was carried out from June through September in accordance with the 2016 Alaska Field Protocol (Million et al. 2016). Most of the fieldwork was carried out by SCA interns Christine DeVries and Nicole Zampieri, along with NPS staff member Bob Peterson. Supervision and guidance was provided by KATM coastal biologist Carissa Turner, AKEPMT Program Manager Chris Overbaugh, and AKEPMT Data Manager Peter Frank. In August, a six person SCA crew assisted with control work at Brooks Camp, and various other NPS staff assisted throughout the season.

Fieldwork included invasive plant surveys carried out in high visitor use locations and controlling populations that were discovered. Priority locations included Brooks Camp, the VTTS road, Fure's Cabin, Grosvenor Lodge, Battle River, Nonvianuk Lake, and various backcountry sites within KATM. Brooks Camp, the VTTS road, and Fure's Cabin were visited monthly for surveys and control work, while most other areas were only surveyed once during this season. Manual and chemical treatment were used throughout the season and all areas surveyed or treated were mapped using a Trimble Geoexplorer Series GeoXT (3000 series) or GeoHX (6000 series) GPS unit utilizing TerraSync and the standard Alaska EPMT data dictionary for KATM. Chemical treatment was carried out at Brooks Camp, Fure's Cabin, Nonvianuk Lake, and Battle River this season, targeting only common dandelions. The herbicide used is called Milestone, which is a broad-leaf specific herbicide with the active ingredient aminopyralid. Manual removal was utilized on all other invasive plants found this season. Water samples were collected to test for presence of *Elodea* eDNA from 12 lakes that were thought to be at the highest risk for becoming infested from float plane visitation. These samples were processed and returned to the Central Alaska Network in Fairbanks for testing.

Results

Overview

Table 1. A summary of Exotic Plant Management efforts since 2014.

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
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)
2016	3	4/25-10/9	43.200 (5.177)	0.300 (1.024)	0.261 (0.185)

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. A summary of herbicide use in KATM in 2016.

Site	2016 Herbicide Mix - Use Data				
	Amount Used (Gallons)				
	June	July	August	September	Total
Fure's Cabin	0.75	0.5	0.375	1.5	3.125
Brooks Camp	0.75	0.7	0.25	0.44	3.125
Battle River		9.5			9.5
Nonvianuk			0.75		0.75

Table 3. Bodies of water sampled in 2016 to test for presence of *Elodea* DNA

Elodea Surveys	
Water Body	Location
Jojo Lake	Park
Kulik Lake	Park
Lake Brooks	Park
Lake Coville	Park
Lake Grosvenor	Park
Hammersly Lake	Park
Naknek Lake	Park
Crosswinds Lake	Preserve
Kukaklek Lake	Preserve
Nonvianuk Lake	Preserve
Naknek River	Bristol Bay Borough
Pike Lake	Bristol Bay Borough

Table 4. Details about areas surveyed during the 2016 field season.

Name	Location	Last Surveyed	Survey or Treatment	# of Visits	Invasive Plants Found
Hammersly Lake	Park	2015	Survey	1	
American Creek	Park	2014	Survey	1	
Coville Lake	Park		Survey	1	
Grosvenor Lodge	Park	2013	Treatment	2	CD, CP
Brooks Camp Developed Areas	Park	2015	Treatment	4	AC, CD, CP, MC, PK, SP
Lake Brooks Side	Park	2015	Treatment	4	CD, CP, PK, SP
New Housing	Park	2015	Treatment	4	CD, CP
Maintenance Yard	Park	2015	Treatment	4	PK, SP
VTTS Road	Park	2015	Treatment	4	CD, CP, MC, SP
5-Mile Pit	Park	2015	Treatment	4	CP, SP, NH
VTTS	Park	2015	Survey	3	
Fure's Cabin	Park	2015	Treatment	4	CD, SP
Portage Trail	Park	2015	Treatment	5	MC
Hallo Bay	Park	2015	Treatment	1	CP
Nonvianuk Ranger Cabin	Preserve	2015	Treatment	2	CD, CP
Alagnak River	ALAG	2015	Survey	1	CD
Amalik Bay	Park	2015	Survey	1	
Battle River	Park		Treatment	1	CD
Ugashik Narrows (FWS)	FWS		Survey	1	CC, CD, CP, JJ, OD, OH, MC, RC, SP, TR, WC
Rapids Camp	Bristol Bay Borough	2015	Survey	1	PK, SP, SS
Lake Camp	Bristol Bay Borough	2015	Treatment	1	FD, PK, SP, SS
FAA Housing	Bristol Bay Borough	2015	Survey	1	AC, CD, FD, NH, OD, SS, WC
NPS Dormitory	Bristol Bay Borough	2015	Survey	1	CC, CD, NH, SM
Crosswinds Lake	Preserve	2015	Survey	1	
Amber Bay	ANIA	2015	Survey	1	

¹ AC= alsike clover (*Trifolium hybridum*), CC= common chickweed (*Stellaria media*), CD= common dandelion (*Taraxacum officinale* ssp. *officinale*), CP= common plantain (*Plantago major*), JJ= Johnny jumpup (*Viola tricolor*), NH= narrowleaf hawkbeard (*Hieracium umbellatum*), OD= oxeye daisy (*Leucanthemum vulgare*), OH= orange hawkweed (*Hieracium aurantiacum*), MC= mouse-ear chickweed (*Cerastium fontanum*), PK= prostrate knotweed (*Polygonum aviculare*), RC= curly dock (*Rumex crispus*), SM= scentless false mayweed (*Tripleurospermum inodorum*), SP= shepherd's purse (*Capsella bursa-pastoris*), SS= sheep sorrel (*Rumex acetosella*), TR= White Clover (*Trifolium repens*), WC= Wild Chives (*Allium schoenoprasum*)

Brooks Camp

Brooks Camp is the most popular destination within KATM due to bear viewing opportunities, fishing, and access to the VTTS. Located at the mouth of the Brooks River, the amount of visitors experienced annually has contributed to this area being the most heavily infested unit in the park. Common dandelion, *Plantago major* (common plantain), *Capsella bursa-pastoris* (shepherd's purse), *Poa annua* (annual bluegrass) and *Matricaria discoidea* (pineappleweed) are all commonly found invasive plants in the Brooks Camp area.

Following the standard set by the 2015 EPMT, this year's team chose not to map or control pineappleweed or annual bluegrass in order to focus on more highly ranked invasive plants (Armstrong and Tourville 2015). Neither plant will be mentioned in the report unless they were found in a new remote location. Control work performed in the Brooks Camp Developed Area (BCDA) consisted of both manual and chemical treatment this year. 2016 was the first year that the EPMT had two certified herbicide applicators, which allowed for better control of the common dandelion infestation in the BCDA. Herbicide was applied to common dandelions in June, July, August, and September at Brooks Camp and all other invasive plants were manually controlled. A six person SCA crew joined the EPMT in August to help with manual control efforts in Brooks Camp.



Figure 5. The SCA crew holding bags of invasive plants pulled at Brooks Camp.

BCDA Campground and Dumpling Mountain Trail

Brooks campground is the only developed camping area within KATM and consists of approximately 2.5 acres of land surrounded by a bear fence. The campground sees very high visitor use, especially in July, and is also passed through by visitors on their way to the Dumpling Mountain trail. Brooks campground contained both common plantain and common dandelion in the 2016 season. Previous EPMT have had to rely on manual control efforts for the removal of dandelions, but this season chemical treatment was utilized within the campground using Milestone herbicide. The

EPMT obtained permissions from the four leaders in the BCDA to apply herbicide and appropriate signage was posted on all entrances to the campground.

In June, the grasses within the campground were already very tall and dense, which likely reduced the number of dandelions that were located and treated. Dandelions in various stages of phenology were located and sprayed with herbicide, flowers and seed heads were collected beforehand to prevent the plants from going to seed after they were sprayed. Common plantains were found and removed manually. The campground was revisited in July, but due to high occupancy, herbicide application was not feasible. A number of common plantains were manually removed, and heads were removed from any dandelions found. July was the first time in 2016 that the Dumpling Mountain Trail was surveyed, and a small patch of common plantain was located and manually removed from the center of the trail near the first large overlook. The campground was surveyed again in August with the help of the SCA crew. Dandelions were retreated with herbicide and plantain was manually removed. *Cerastium fontanum* (mouse-ear chickweed) was recorded in the campground for the first time in August, although it was not removed due to lack of blooms for positive ID. It was mapped and should be confirmed and removed next season. Another survey of the Dumpling Mountain trail revealed more common plantains on the trail located closer to the trailhead than the population from July. In September, the campground was informally surveyed and no invasive plants were found.

Employee Facilities

Employee housing and facilities for the National Park Service (NPS) and Brooks Lodge employees are primarily located in the northern portion of the BCDA. NPS cabins are situated in an area referred to as “park avenue” and Brooks Lodge employees have cabins surrounded by a bear fence in an area called “Tuckerville”. Common dandelion, common plantain, shepherd’s purse and white clover have all been found in this area in previous years.

In June, dandelions were sprayed with herbicide within Tuckerville and a single shepherd’s purse was removed near the lodge lounge building. In July, dandelions in Tuckerville were retreated with herbicide and one shepherd’s purse was manually removed. A number of common plantains were found near the lodge lounge building and on the northern side of the generators, as well as a few individuals scattered along park avenue. Common dandelions were retreated once again in Tuckerville in August, as well as the manual removal of common plantain around the lodge lounge, along Park Avenue and near the generators. Surveys in August also discovered a large patch of *Polygonum aviculare* (prostrate knotweed) in the leach field between the NPS bathhouse and Tuckerville, which was removed with the help of the SCA crew. The adjacent field that is surrounded by a bear fence had a number of common plantains, which were also removed by hand. In September, Tuckerville was retreated with herbicide.

Visitor Center Area

The Visitor Center (VC) area encompasses the area between the ranger station and the VC, including the auditorium, picnic area, bathrooms, and food and gear cache. This area was surveyed in detail in June with no invasive plants found. In August, this area was revisited and two individuals of common chickweed and one common plantain were removed from the lake facing side of the

bathrooms. In September, two common dandelions were sprayed with herbicide near the ramp to the auditorium.

Cultural Site

The cultural site at Brooks Camp is an area where a building was constructed around the site of a prehistoric dwelling known as a *barabara*. This location is accessed by a short trail from the auditorium and the area surrounding the site is maintained by brush mowing. In the past, this location had been heavily infested with dandelions, so it has been a main focus for the EPMT over the last few years. Shepherd's purse had also been observed at this location in the past, but it was not seen this season.

In June, the cultural site was visited and dandelions were found in all stages of phenology. Herbicide was applied and flowering heads were removed. The area was revisited in July and retreated with herbicide. In August, the area was surveyed one day to estimate the amount of herbicide that would be needed and when it was revisited to spray the following day, many of the dandelions had been cut by brush mowing for an upcoming archeological survey and could not be located for spraying. The remaining dandelions were treated with herbicide. A return visit in September revealed a dense infestation of common dandelions, likely due to the brush mowing in August exposing the plants to more light than normal. The dandelions were retreated with herbicide.



Figure 6. C. DeVries mixes herbicide to spray at Brooks Camp

Brooks Lodge

Brooks Lodge is the concessioner that provides lodging and amenities to guests at Brooks Camp. The lodge is open from June through mid-September and experiences high visitation by bear viewers and anglers arriving by floatplane or boat. Common dandelion, common plantain, shepherd's purse, and *Trifolium hybridum* (alsike clover) were found and removed from the lawn and on trails surrounding lodge facilities this season. Efforts were made to carry out control work during hours where visitors were away from their cabins.

Permission to spray herbicide on Lodge property was granted for the first time this year. Common dandelions were treated with Milestone herbicide in June, July, August, and September. Dandelions were most concentrated in the lawn between the marsh overlook cabins, around the bathhouse, and in the grass between the lodge and camp trail. In June, small populations of shepherd's purse and common plantain were removed around the lodge bathhouse. In July, one individual of alsike clover was found and removed from Skytel, as well as one common plantain. In August, a few individuals of shepherd's purse were removed near the fish freezing building.

Mouth of Brooks River

The mouth of Brooks River is frequented by bear viewers and people passing through to get to the falls platform or Lake Brooks side. Vehicles are often used in this area to transport items from the barge, for maintenance purposes, and to pick up visitors to go to the VTTS. This makes this area very important to monitor and treat for invasive plants because infestations can quickly spread to other areas in the park from vehicles and foot traffic. This area typically has a lot of shepherd's purse, some common dandelions, and prostrate knotweed.

In June, common dandelions were sprayed with herbicide along the spit road at the mouth of Brooks River. Large amounts of shepherd's purse were found all along the spit road and spit, but there was not enough time to control all of it. In July bear activity was high, but we were able to chemically retreat the dandelions in the area. Prostrate knotweed was found near the entrance to the bridge in front of the platform, but was unable to be controlled due to bear activity. In August, the EPMT had planned to have the SCA crew spend a significant amount of time removing shepherd's purse from the spit, but unusually high waters made it impossible. The prostrate knotweed was removed from near the bridge entrance, dandelions were retreated with herbicide, and a small amount of shepherd's purse was pulled along the trail. In September, a member of the EPMT revisited the site of the prostrate knotweed near the bridge entrance and pulled all individuals that were found.

Barge Landing and Beaver Pond

The new barge landing was constructed in 2014 to help facilitate the construction of new employee housing and installation of a new elevated bridge over the Brooks River. Due to ongoing legal issues, the new barge landing as well as the parking area and road were closed and not able to be surveyed this season. The road to the new barge landing is observable from the VTTS road and shepherd's purse could be seen but not controlled. Any invasive plants found on the VTTS road side were removed.

Brooks Falls Trail and Platform

Brooks Falls is the most visited area of Brooks Camp for bear viewing, and the trail is also used by anglers to access parts of the river. In the past, common dandelions, *Phleum pratense* (timothy grass), and *Ranunculus acris* (tall buttercup) had been found on the falls trail but there was no evidence of these species this year. Underneath the platform there was a dense infestation of shepherd's purse, which can be difficult to control because the area beneath the platform was closed from June 15-August 15.

The shepherd's purse beneath the falls platform was partially manually controlled in June, although there were thousands of seedlings and the EPMT had to return to King Salmon before all plants were removed. The island was surveyed in June and found to be free of invasive plants. During the team's time at Brooks Camp in July and August, the area below the platform was closed. Shepherd's purse was visible immediately below the platform. In June and July, the trail was free of invasive plants, but in August one individual of shepherd's purse was removed from the trail near the entrance to the platform.



Figure 7. Bear activity is frequently high near the falls platform.

Lake Brooks Side

Lake Brooks side consists of housing for NPS employees, a boat launch, a picnic area, and various other structures all situated on Lake Brooks. Float planes will land on Lake Brooks for sport fishing or when there is an east wind that prevents them from landing on Naknek Lake, and visitors will be shuttled back to the BCDA in a bus. Common dandelion, common plantain, and shepherd's purse have all been found in this area in the past.

This year the Lake Brooks side area was treated manually each month for common dandelion, common plantain, shepherd's purse, and prostrate knotweed. Only a small number of common dandelions were found along the road, so they were manually removed to save time instead of returning to the other side of the river to mix herbicide. A common plantain infestation was concentrated in front of BL2, the "Y" in the road before BL1, and a very dense infestation in the field before BL1 where there used to be a maintenance yard. A particularly dense infestation of shepherd's purse was removed from the small field next to the old marina building near the picnic area.

The Valley of Ten Thousand Smokes

The Valley of Ten Thousand Smokes is an extraordinary geologic formation created during the 1912 Novarupta eruption. Expeditions to the site of the eruption led to the protection and eventual

establishment of KATM. The VTTS sits only 23 miles away from the BCDA, and visitors can take the Valley tour; a service provided by the Lodge with the assistance of a park interpreter. The tour stops at a few sites along the road and takes visitors along trails into the VTTS, which creates an opportunity for the spread of invasive plants into the VTTS area.

Valley Road Administrative Area

Between mile markers 1 and 5 along the Valley of Ten Thousand Smokes Road (VTTSR) lay several areas of interest for the EPMT. The Valley Road Administrative Area (VRAA) encompasses the new employee housing area and the maintenance building. Since the beginning of the new employee housing construction in 2013, EPMTs have documented shepherd's purse and pineapple weed around the housing loop. During the 2016 season, a few infestations of shepherd's purse and a new infestation of common plantain growing around the new cabins were documented and removed. As long as the construction continues this site should remain a priority for the EPMT. The maintenance building was surveyed in June, July, and August and should remain a priority for EPMTs as vehicular traffic in and out of the yard grants potential for spread of invasive plants elsewhere. Scattered infestations of Shepherd's Purse were found along the outside perimeter of the fence, along the sidewalk surrounding the building, and in various locations under vehicle parking within the maintenance yard. Prostrate knotweed was also found growing densely outside of the fence and was manually controlled with the help of the SCA crew in August.

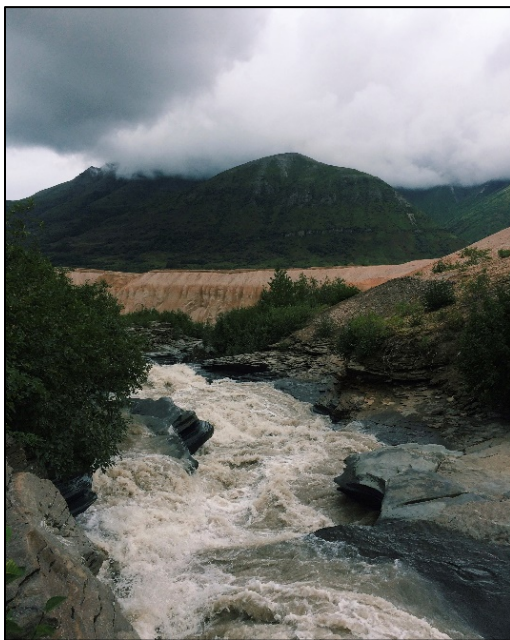


Figure 8. A view of the Lethe River in the Valley of Ten Thousand Smokes.

5-Mile Gravel Pit

All fill material used for construction and maintenance within the BCDA and along the VTTSR is harvested from the 5-Mile Gravel Pit. The disturbed nature of the site holds potential for new invasive plants to quickly establish themselves, so it is imperative to survey this site carefully and

repeatedly. Shepherd's purse, *Crepis tectorum* (narrowleaf hawksbeard), pineapple weed, *Trifolium pratense* (red clover), common plantain, and *Vicia cracca* (bird vetch) have been documented and treated in the past at the pit. In June and July of 2016 a large infestation of common plantain was documented and treated along the electric fence. In July, shepherd's purse was found and treated in a few locations, mostly near the entrance of the pit. In August, a few individuals of narrowleaf hawksbeard were located within the pit, but in a new location when compared to previous years. This is the only known infestation of narrowleaf hawksbeard within the park, so this should be a priority for control efforts in the future. The sites of the previously found red clover and bird vetch were revisited, but plants were not found.

Valley of Ten Thousand Smokes Road

The VTTSR is the 23-mile road from the lower platform at the mouth of Brooks River to the Three Forks Visitor Center in the VTTS. Beyond the 5-mile gravel pit, there are a few pulloffs and stops that the Valley Bus utilizes along the way to the visitor center. The 2015 EPMT surveyed the entire length of the road on foot, and suggested that this only be done every few years. The 2016 EPMT surveyed at highly trafficked locations including the Research Bay Overlook, bathrooms, the pulloff before the third river crossing where the grader is kept, and points of previously found invasive species. Shepherd's purse, common chickweed, pineapple weed, tall buttercup and bird vetch have all been documented along the VTTSR. Tall buttercup has only been documented once, in between the parking lot and the Y, which was revisited and not found. Bird vetch has been documented after the first river crossing and at the 13.5 mile marker, which were revisited each month and not found. The EPMT also noted that the 2015 EPMT treated a small patch of pineapple weed underneath the maintenance grader due to its small size, isolation, and proximity to the VTTS. When the site was revisited in 2016, the infestation had grown exponentially and it was determined that manual treatment would no longer be effective.

Mouse-ear chickweed was positively identified within Brooks Camp along the VTTSR between the lower platform and the parking area trailhead, along the edge of the meadow. The population was found in June and the EPMT took photos to send to Justin Fulkerson at the University of Alaska for a positive identification before treating. When the area was revisited in July, many had begun going to seed. The infestation was manually treated, although the invasive chickweed may have been interspersed with a native chickweed species as well. While in seed, the native and the invasive chickweed are nearly impossible to tell apart. Considering that J. Fulkerson had confirmed the presence of mouse-ear chickweed, the EPMT manually removed all chickweeds along this section of the VTTSR. This infestation should be a high priority for future EPMTs to limit the spread elsewhere in the park, and should be surveyed in June when positive identification will be easier.

Ukak Falls, Margot Falls, and Windy Creek Trails

Located at the Three Forks VC in the VTTS is a trailhead that leads to the Ukak Falls Trail and the Confluence Trail. These trails receive considerable visitation when the lodge is open and running tours. The only invasive species ever recorded along the trails is annual bluegrass, and it was not found in 2016. About a mile down the road from the VC lies the Windy Creek Trail, which is one of the primary routes backpackers take into the VTTS who plan to hike along the Buttress Range to the

huts or along Solstice Ridge. Common plantain has been found in the past along this trail but was not found again when surveyed in July. No invasive plants were found along the Windy Creek Trail and well beyond along the Solstice Ridge, though a Trimble survey line was only taken until the end of the Windy Creek Trail. The Margot Falls Trail, located near the bathrooms on the VTTSR was surveyed with the help of the SCA crew in August and no invasive plants were found.



Figure 9. C. DeVries uses the Trimble while surveying the Confluence Trail.

Naknek Lake

Naknek Lake is the largest lake contained within a National Park and provides access to a number of popular locations within KATM. In addition to traffic between Lake Camp and Brooks Camp, the lake is also navigated by many fishermen and kayakers seeking to complete the Savonoski Loop. The Savonoski Loop is an 86 mile canoe/kayak trip beginning at Brooks Camp through Naknek Lake, Grosvenor Lake, and the Savonoski River, requiring travelers to camp at many locations along the way. Paddlers often camp on Spruce Island near the end of their trip in the Iliuk Arm. Margot creek is another popular location on Naknek Lake that is frequented by anglers. In addition to surveying for invasive plants in this area, a water sample was taken from the lake to test for presence of *Elodea* DNA.

Lake Camp

Lake Camp is the primary access point for boats into the park (specifically to Brooks Camp) and is the only place on park land accessible by vehicle from King Salmon. It lies just west of Naknek Lake at the mouth of Naknek River. It is heavily trafficked during the summer season and has become a hub for invasive plants. When surveying in July, *Rumex acetosella* (sheep sorrel) was identified in incredibly high numbers. In the past, sheep sorrel has been treated with herbicide, but this year herbicide use was only approved for common dandelions. Shepherd's purse and prostrate knotweed were also identified, mostly growing along the shore and on the sides of the roads leading to the lower parking lot. *Leontodon autumnalis* (fall dandelion) was found in small but dense patches around the picnic tables and in a few locations around the upper and lower parking lots and was manually treated. In previous years, common chickweed, common dandelion, and *Leucanthemum vulgare* (oxeye daisy) have also been found, but were not found again this year.

Bay of Islands

The Bay of Islands lies in the North Arm of Naknek Lake. Previous years EPMTs surveyed the islands extensively. During the 2016 season, the Bay of Islands was not surveyed. It is recommended for future EPMT's to do a more thorough survey of the Bay of Islands every few years, due to the ease of access for visitors from Brooks Camp.

Fure's Cabin

Fure's Cabin sits within the Bay of Islands on Naknek Lake. Roy Fure built the cabin in 1926 as his winter home, and it is now a public use cabin maintained by the NPS. There is also a portage trail, utilized by visitors completing the Savonoski Loop, leading from the cabin on Naknek Lake to Lake Grosvenor. Since 2011, the infestation of common dandelion has been chemically treated. This is the first year that dandelions at Fure's Cabin were retreated multiple times in the same year, with treatments taking place in June, July, August, and September.

In the past, mouse-ear chickweed, pineapple weed, annual bluegrass, and shepherd's purse have been documented at the cabin as well. In June, only common dandelions were identified and treated at Fure's Cabin. The infestation begins about half-way up the trail from the beach to the cabin and grows denser near the cabin. The population is most dense in the fields surrounding the cabin. Only a few dandelions were identified on the portage trail beyond the outhouse. The short trail to the rocky beach is also heavily infested, and was partially inundated with lake water when we returned in July. In July, about $\frac{3}{4}$ of the way down the portage trail from Naknek Lake to Lake Grosvenor, a small infestation of mouse-ear chickweed was identified and manually treated. It was found again in August, slightly closer to the Naknek Lake side of the portage. This infestation has been found in previous years, but not consistently. This exact location should be of high priority to revisit for future EPMTs to prevent further spread.



Figure 10. B. Peterson applies herbicide in the field next to Fure's Cabin.

Idavain and Dumpling Creeks

Idavain and Dumpling Creeks are popular fishing locations that are frequented by anglers arriving by boat or floatplane. In previous years, EPMTs have surveyed the mouths of these creeks and only a few individuals of pineapple weed have been found. This year, limited time at Brooks Camp in June

prevented surveys from taking place and bear activity was assumed to be too high later in the season. Next June surveying this area should be a priority.

Margot Creek and Spruce Island

Within the Iliuk Arm of Naknek Lake lie many camping spots utilized by anglers or visitors completing the Savonoski Loop. Spruce Island is found near the mouth of the Savonoski River. The campsite located on the island was surveyed and no invasive plants were found. Also within the Iliuk Arm lies the outlet of Margot Creek, a popular fishing destination. The Margot Creek outlet and angler trails leading around the creek were surveyed with nothing found. Shepherd's purse was discovered in 2015 along a few gravel bars, but was not rediscovered when surveyed in June of this season. Several nesting arctic terns were encountered that exhibited territorial behavior and made it difficult to survey the gravel bars, but not impossible. Should the sites be revisited in the future, note the possible presence of nesting birds early in the season.

Lake Brooks

Lake Brooks sits on the southwestern side of Brooks Camp and is far less traversed than Naknek Lake. Nonetheless, there are a few popular fishing spots as well as some campsites on the lake. The mouth of Headwaters Creek, which is primarily visited by anglers, was surveyed with no invasive plants found. Missy's Island was visited for the first time in 2015 in search of an old camp site, but the EPMT could not find it. This year, a trail was found and surveyed, but it was determined to be a bear trail. After continuing to search, the trail to the campsite was located along the only exposed gravel beach in the cove. The trail and campsite were free of invasive plants. A water sample was collected from Lake Brooks to test for *Elodea* DNA presence.

Lake Grosvenor

In 2013, Lake Grosvenor and Grosvenor Lodge were surveyed for the first time and pineapple weed, shepherd's purse, annual bluegrass, and common dandelion were found (Landry and Voznitza, 2014). Most of the invasive plants found in the area were on Grosvenor Lodge property. At the suggestion of the 2015 EPMT, this year's team reached out to the lodge owners and were invited to come survey on the property and manually remove any invasive plants found. The lodge was first visited in June and a number of common dandelions were removed from the lawn, especially the area between the boat landing and where the lodge buildings begin. The lodge was revisited in August during a trip to Fure's Cabin and more dandelions were manually removed, as well as one common plantain. Grosvenor Lodge agreed to continue to allow the EPMT to survey in the future, and this should be a high priority as no other invasive plants have been located in the area. In both June and August, the EPMT attempted to boat to the big island on Lake Grosvenor where people often camp while paddling the Savonoski Loop, but wind was too strong for the small boat to make it there for a survey. Water samples were taken from Lake Grosvenor and nearby Jojo Lake for *Elodea* testing.

Lake Coville

Lake Coville is located at the outlet of American Creek and connects to Lake Grosvenor at the site of Grosvenor Lodge. This lake is often traveled to by floatplanes and boaters in order to access lower American Creek. In 2016, an employee from Grosvenor Lodge mentioned to the EPMT that he had seen dandelions at the mouth of Twin Lakes Creek on Lake Coville, so the site was visited in August

for a survey. Basal rosettes of dandelions were found, but it could not be determined if they were native or invasive and, given the remote location, the rosettes were left untreated. This area should be revisited earlier in the season in 2017 to look at the flowers and determine if they are native or invasive. A water sample was taken from Lake Coville to be tested for presence of *Elodea*.

Hammersly Lake

Hammersly Lake is a remote alpine lake that forms the headwaters of American Creek. The lake is primarily visited by fishermen and rafters that will travel down American Creek. This site was visited for the second time by the EPMT this year and the main beach on the northern side of the lake was surveyed and free of invasive plants. A water sample was taken to be sent in for eDNA testing for presence of *Elodea*.

American Creek

American Creek is located in the northern portion of the park, originating from Hammersly Lake and ending at Lake Coville. The creek itself originates in alpine tundra and then descends through canyons and ravines into moist tundra and upland spruce. It is used by various fishing outfitters, lodges, and a few rafters every year. KATM law enforcement rangers typically raft the creek twice a year and stop at various fishing spots and camping spots along the way. This year, the EPMT rafted the entire length of American Creek for the first time. The route that is used by the law enforcement rangers was followed, as they have a guide book with tips and advice on popular campsites and stops.



Figure 11. The EPMT preparing to raft American Creek on the beach of Hammersly Lake.

Along the route, the following locations were surveyed: Hammersly Lake beach, Squiggle Lake, Trail Camp, Pancake Camp, Big Rocks Camp, Camp F1, Aquarium Camp, Cliff Hole Camp, Camp F3, Gravel Bar Camp, Log Pad Camp, Right Camp, Violation Camp, Boat Parking, and Ranger Station Pickup. Not every campsite was surveyed because the water was moving too fast to stop, or the campsites were unable to be located, especially on upper the upper river. The stops missed included Landing Lake, Char Hole Camp, Dandelion Camp, Canyon Camp, Camp F2, and Checkpoint Alpha Camp. No invasive plants were found at any point along the Creek. There were a number of native dandelions observed along the river.

Battle River

Battle River is located in the northern portion of the park near the border of the preserve. This location was suggested for a visit by the management at Katmailand because of a dense infestation of dandelions present at the private inholding known as Battle River Wilderness Retreat. The EPMT reached out to the manager, Tim Conway, and permission to apply herbicide to the common dandelions was granted. The small lodge is located at the headwaters of Battle River where it meets Battle Lake. The population of common dandelions was incredibly dense on the property, but did not spread on to NPS land. Multiple hours were spent with two applicators applying 9.5 gallons of herbicide mixture total. This area should be of great concern in the coming years and should be revisited for herbicide treatment at least twice a season.



Figure 12. A dense infestation of common dandelions at Battle River Wilderness Retreat.

Outer Coast

The outer coast of Katmai has been the site of villages, canneries, farms, and mining operations over its long history of anthropogenic use. In recent history, the outer coast has been a popular destination for bear viewing in areas like Geographic Harbor, Hidden Harbor, and Hallo Bay. KATM has ranger cabins at Amalik and Swikshak Bays, and private lodges are located at Kaguyak and Kukak Bays. The outer coast is one of the most difficult areas to visit during the season due to challenging weather, so it has been sporadically surveyed whenever logistics have allowed.

Amalik Bay

Amalik Bay is located on the southern portion of Katmai's coast and experiences a significant amount of visitation by boaters. KATM has two interpretive rangers stationed at a cabin in the bay and law enforcement rangers stay near the cabin in a tent a few times a year as well. Amalik Bay was visited in late June on a trip to drop off a law enforcement ranger and a brief survey was done around the cabin, trail to beach, trail to outhouse, and surrounding areas. In previous years the surveys have been more extensive, but bad weather limited time spent on the ground this year. Invasive plants have not been found in this area in the past, and none were this year. Amalik Bay should continue to be monitored, although visits with extensive surveying can be limited to every few years.



Figure 13. The ranger cabin at Amalik Bay.

Hallo Bay

Hallo Bay is among the more highly visited sites in the park because of high concentrations of brown bears due to the abundance of food provided by the vast sedge meadows and tidal flats. Many visitors fly in to this area on float and wheeled planes from areas like Homer and Kodiak, which are hotspots for invasive plants. KATM has rangers and researchers stationed out of a campsite on the bay, and they can be vectors for introducing invasive species as well. It is important for this area to be surveyed at least once a year because of its high visitation rate to ensure that any invasive plants are found early. In 2016, Hallo Bay was visited in late June during a trip to pick up the interpretative rangers for their weekend off. The visit was brief, but the campsite, trail to the beach, and surrounding areas were surveyed. In past years, common dandelion and common plantain were both found within the NPS ranger campsite. In 2016, a small infestation of common plantain was found and removed within the ranger campsite, but no common dandelions were identified. The areas surveyed outside of the campsite were free of invasive plants.

Katmai National Preserve

Nonvianuk Ranger Cabin

The Nonvianuk Ranger Cabin is located near the headwaters of the Nonvianuk River, on the western end of Nonvianuk Lake. The cabin is primarily used by law enforcement rangers that patrol the area multiple times a year. The cabin is surrounded by a few trails; one leading beyond the outhouses, one to the boat parking, and the longest of which leads to the float plane drop off upstream from the cabin. No invasive plants have ever been recorded directly around the cabin or on the trails to the outhouse and boat landing. The majority of the existing infestations lie along the river bank near the float plane drop off, where small patches of common plantain have been found as well as sizeable infestations of common dandelions. Previous EPMTs noted that the population of common dandelions along the bank may have hybridized with a native lookalike, the horned dandelion (*Taraxacum ceratophorum*). It would be impossible to determine true hybridization in the field (Brock 2004) and past EPMTs have consistently treated all dandelions found in the area.

A preliminary site visit was done at the end of June to survey and determine the extent of the infestation. The infestation was found to occupy the same length of the beach as noted in previous years. No exotic plants were found around the cabin or on the trails extending from the cabin. When revisited in early August, the infestation of common dandelions along the beach was treated with herbicide. No other invasive plants were found. This area should be a priority to retreat with herbicide in coming years. A water sample was taken from Nonvianuk Lake, as well as nearby Kulik Lake, and Kukaklek Lake to test for presence of *Elodea*.

Crosswinds Lake

Crosswinds Lake was visited in August with the main objective of obtaining a water sample to test for the presence of elodea DNA. Crosswinds is a popular location for fishermen and bear viewers, so many planes land on the lake throughout the summer months. The angler trails and campsite were surveyed for invasive plants and none were found. An additional trail on the other side of the river was not surveyed due to inclement weather moving in, so it would be worthwhile to conduct another survey in the next couple of years.

Alagnak Wild River

The Alagnak Wild River flows from Kukaklek Lake (within KATM boundaries) to the Kvichak River. KATM assumes administrative responsibility of 69 miles of the River, beginning at the preserve boundary to the west of Kukaklek Lake. There are no NPS facilities located along the river. Many areas along the river are private inholdings with lodges and native allotments. This makes surveying difficult as the EPMT must be sure to remain on park land or have gained permission from the private landowners. 2015 was the first year KATM EPMT attempted a survey and the only location where invasive plants were identified was on a private inholding at the confluence of the Alagnak and Nonvianuk Rivers. This area was revisited this season for observation. The private inholding is about 40 acres in size. The portion closest to the confluence seems to be used as a camp spot with a fire ring. From the boat, a sizeable infestation of common dandelions was observed, with an estimated cover of 60-80%. It should be a goal of future EPMTs to obtain permission to access this inholding to chemically treat the dandelion infestation.

Along the Alagnak River the EPMT boated as far as the falls in order to determine if they are passable for work in future seasons, which they are not. At a stop to look around, a well-defined portage trail was discovered with recent footprints. There were no invasive plants identified along the portage trail.

Aniakchak National Monument & Preserve

Aniakchak National Monument & Preserve is one of the most remote and least visited units of the National Park Service. Located about 130 miles south of KATM on the Alaska Peninsula, ANIA is another park that is protected due to its volcanic history. Despite the distance, ANIA is managed by the same staff as KATM. Previous surveys have shown common dandelions growing along the Aniakchak River (Shepherd and Bartley, 2010). Visits to other areas in 2012 and 2015 revealed no other invasive plant species. In 2016, a member of the EPMT was able to visit Amber Bay while assisting with a marine debris survey and no invasive plants were found.

Ugashik Narrows

In 2016, the FWS in King Salmon asked the EPMT to assist them with a *Hieracium aurantiacum* (orange hawkweed) problem that they have on a private inholding within the Alaska Peninsula National Wildlife Refuge. The EPMT visited the site in late June and found an incredibly dense infestation of orange hawkweed as well as at least twelve other invasive plants, some of which have rather high invasiveness rankings. These invasive plants are thought to have come from contaminated seed that was given to the landowners by the Department of Natural Resources (DNR) to help stabilize the river bank a couple of decades ago. This initial visit consisted of mapping the orange hawkweed population only, as mapping all the other species would be very time consuming and the objective of the FWS was to remove only the orange hawkweed. A return visit to treat the orange hawkweed with herbicide was planned, but bad weather and busy schedules prevented it from being carried out this season. An assessment of the area was written up and submitted to FWS. Next year it should be a priority to get out to this site by early June to apply herbicide and retreat later in the season as well.



Figure 144. N. Zampieri surveys amongst a sea of invasive plants at the Ugashik Narrows.

Bristol Bay Borough

The Bristol Bay Borough consists of King Salmon, Naknek, and South Naknek. Most of the visitors to KATM travel through King salmon, so this area can be a dangerous source of invasive plant seeds that can eventually travel into the park.

NPS Administered Properties

Federal Aviation Administration (FAA) housing, where many of the permanent NPS staff live, was visited in July. The areas around the community building were surveyed and mapped, as well as all the properties along Mosquito Coast Rd. Most of FAA housing has been monitored consistently throughout the history of KATM EPMT. It is densely infested with many species, some of which are not found anywhere else in the area. The infestation of fall dandelion around FAA housing is larger and denser than anywhere else surveyed this season. There is also a very high density of alsike clover. Both species cover almost all of the roadsides and ditches along Mosquito Coast Rd. and

around the community areas. There were a few houses that had dense infestations of oxeye daisies. Narrowleaf hawksbeard, common dandelion, and sheep sorrel grow sporadically around houses and along the roadside. This year, a dense infestation of *Allium schoenoprasum* (wild chives) was found growing around the house at the corner of Mosquito Coast Rd. and Beluga. In addition to these surveys, a water sample was taken from the NPS float plane dock on the Naknek River to test for *Elodea*.

Non-NPS Administered Properties

Rapids Camp was visited in July, where a dense infestation of sheep sorrel was identified growing along the perimeter of the parking lot. Prostrate knotweed was also found growing along the beach. Interspersed with the prostrate knotweed was a small population of shepherd's purse, which has not been found at Rapids Camp in the past. The common chickweed found in previous years was not found again. Along the Alaska Peninsula Highway, the known infestation of bird vetch was revisited for monitoring. It is a dense but isolated population. Pike Lake, located off the road to Lake Camp, is a lake where pilots often keep their floatplanes early in the season before Naknek River is safe to land in. A water sample was taken from Pike Lake to test for *Elodea* DNA presence.



Figure 155. N. Zampieri maps an infestation of bird vetch along the Alaska Peninsula Highway.

Education and Outreach

Education and community outreach are an integral part of invasive plant management. Invasive plants are often spread and introduced to new areas due to human negligence, so raising awareness about how invasive plants are spread can be an important part of prevention. This applies to the community in King Salmon, visitors from all over the world, and all NPS employees that enter the park.

The 2016 EPMT volunteered with the Naknek Library to help out with a children's science day during Fishtival weekend. The FWS typically puts on a science camp for high school kids in September which the EPMT assists with, but the camp was not put on this year.

Outreach materials were generated by the 2016 EPMT and made available at the visitor centers in both King Salmon and at Brooks Camp. A flyer about the aquatic invasive *Elodea* was made to educate the public about identification, methods of spread, and ecological dangers associated with the plant. The EPMT also generated a KATM specific invasive plant identification guide that detailed the appearance, habitat, distribution, phenology, and control methods for each invasive that has been found in the park. A smaller, Brooks Camp specific version of this guide was made for the SCA crew that helped with control efforts in August. To help raise awareness about the EPMT efforts in KATM, the science communicator for the park requested a blog post about the American Creek trip, which was published on the KATM blog. Several other posts were made about native seed collection and invasive species control methods.

Prevention and Restoration

The most effective form of invasive plant control is, by far, prevention of establishment in new areas. Identifying sources and vectors of invasive plant seeds can save an enormous amount of time and money if they can be mitigated before the plants enter the park. Previous EPMTs have installed boot brushes and inspected heavy machinery that would enter the park to prevent the transport of seeds. Restoration of disturbed areas is another way to prevent establishment of invasive plants. At Brooks Camp, ongoing construction requires ongoing revegetation and restoration. The 2011 and 2012 EPMT suggested restoration techniques based on different disturbance types, although restoration projects have not been routinely carried out at KATM after construction occurs (Connealy and Parker, 2013). In 2013, some revegetation efforts were carried out by distributing seeds in disturbed areas, but no projects have been carried out since. A seed bank has been established at KATM, with contributions from 2013 through 2016 that consists of seeds from *Calamagrostis canadensis* (blue-joint grass), *Achillea millefolium* (yarrow), *Epilobium angustifolium* (fireweed), and *Geum macrophyllum* (large-leaf avens) collected in KATM. Construction of new housing and the upcoming new bridge project greatly necessitate vigilant revegetation and restoration efforts on the part of the EPMT.



Figure 166. C. DeVries collects fireweed seeds at Brooks Camp.

Disposal Methods

Disposal methods for invasive plants at KATM have varied over the years, including sterilization of plants in an oven, burying plants at the dump, and incineration in burn barrels or the incinerator at Brooks Camp. The incinerator has become the standard for invasive plant disposal since 2013 in KATM. All invasive plant material should be incinerated as soon as possible after collection to minimize the chance of ruptured bags and accidental spread of seeds. The EPMT should remove as much soil as possible from the manually controlled plants and allow plants to dry out if they are wet so they will burn more easily. If the Brooks Camp incinerator is not available, other disposal methods have been proposed (see Anderson and Lindsey, 2014).

Phenology

Plant phenology is important information for the EPMT to consider for effective management of invasive plants. Knowledge of plant lifecycles and timing can be helpful for scheduling control efforts to avoid allowing invasive plants from going to seed. Phenology is likely to vary from year to year as it is dependent on environmental conditions, which are highly variable. This data should be an example of the general trend for phenology of plants within KATM. Many of the invasive plants within KATM tend to flower as early in the season as May or June, including common dandelion, sheep sorrel, and shepherd's purse. This should be considered when planning and scheduling control work in the more highly infested areas like Brooks Camp.

Table 5. A phenology log displaying approximate dates of first flower and seed set for invasive plants commonly found in KATM and the Bristol Bay Borough.

Taxon	Common Name	Approximate Date of First Flower	Approximate Date of First Seed Set
<i>Capsella bursa-pastoris</i>	Shepherd's Purse	Early May	June 2
<i>Crepis tectorum</i>	Narrowleaf Hawksbeard	June 22	Mid-July
<i>Hieracium umbellatum</i>	Narrowleaf Hawksweed	July 28	Mid-August
<i>Leontodon autumnalis</i>	Fall Dandelion	Early July	Mid-July
<i>Leucanthemum vulgare</i>	Oxeye Daisy	June 22	Mid-July
<i>Matricaria discoidea</i>	Pineappleweed	June 5	Mid-August
<i>Plantago major</i>	Common Plantain	June 5	Early July
<i>Polygonum aviculare</i>	Prostrate Knotweed	July 9	Late August
<i>Ranunculus repens</i>	Creeping Buttercup	June 30	Mid-July
<i>Rumex acetosella</i>	Sheep Sorrel	June 2	Late June
<i>Stellaria media</i>	Common Chickweed	June 28	Late July
<i>Taraxacum officinale</i> ssp. <i>officinale</i>	Common Dandelion	April 25	Early May
<i>Vicia cracca</i>	Bird Vetch	July 27	Mid-August

Recommendations for the NPS and 2017 Field Season

Have one EPMT member become certified to spray herbicide again to increase the impact that the EPMT can have on invasive plant infestations. Some locations with dense infestations, such as Fure's Cabin and Battle River Wilderness Retreat, necessitate having two certified applicators to make treatment feasible in a realistic amount of time.

Get permission to spray species other than common dandelion – i.e. sheep sorrel and fall dandelion at Lake Camp.

Spend time each month treating invasive plants on NPS administered properties in King Salmon. The common dandelion infestation is very dense around the dorm and other invasive plants need to be controlled at the dorm, FAA housing, and at the float dock.

Form a partnership with FWS that allows chemical treatment of invasive plants on FWS property in King Salmon to prevent invasive plants from spreading into KATM.

Revisit the Ugashik Narrows with FWS to spray orange hawkweed at least twice in the season. This will require many gallons of water to mix herbicide, so be sure to bring at least 3 jugs.

Begin with chemical treatment of dandelions at Brooks Camp, Fure's Cabin, Nonvianuk Ranger Cabin, and Battle River Wilderness Retreat in early June and try to retreat each population at least once in the season.

Educate NPS staff about invasive plants and prevention methods while the whole staff is in King Salmon in May. Backcountry rangers and law enforcement staff can be provided with guides so they have an idea of which plants to look out for.

In years past, the EPMT put on children's programs at the King Salmon Visitor center, which is a great way to raise awareness about invasive plants. Unfortunately, a busy field season in 2016 prevented the EPMT from doing a children's program. Past years EPMT have also had a table at the Fishtival Bazaar where they passed out information on invasive plants to members of the community, but the 2016 EPMT was in the field during the Bazaar this year. Both of these outreach opportunities should be taken advantage of and planned for in future years.

Develop a program early in the season to give to kids at the visitor center in King Salmon.

Continue to update and make new outreach materials about native and invasive plant ID, *Elodea* risks and prevention, etc.

Try to gain permission from the Air Force to treat invasive plants around headquarters.

Contact the Department of Transportation to try to get permission to chemically treat the *Vicia cracca* along the Alaska Peninsula Highway.

Contact private lodges early in the season to try to initiate surveys on their property before they reach the busy season.

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