Acadia National Park
National Park Service
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Resource Stewardship and Science

Exotic Plant Management in Acadia National Park, Maine

2018 Annual Report

ACAD NR Report #: 2019-01

ON THE COVER
Exotic Plant Management Team (EPMT) Member James (Jim) Burka and Data Manager Nicholas (Nick) Stevenson perform foliar herbicide applications on exotic Canada thistle on Baker Island, 21 August 2018. (NPS Photo)

Exotic Plant Management in Acadia National Park, Maine

2018 Annual Summary Report

ACAD NR Report #: 2019-01

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Table of Contents

Page #

List of Figures

Page #

List of Tables

Page #

Executive Summary

In 2018 the Acadia National Park (ANP) Exotic Plant Management Team (hereafter EPMT) systematically surveyed 1,112 acres of forest, wetland, riparian and other habitats for the presence of Invasive Exotic Plant (IEP) species prioritized for management (see **Figure 1** below). This is an increase over 2017, in which 936 acres were surveyed. Invasive plants were managed at 91 sites in 2018, with treatment area totaling 3.92 infested acres.* 73 sites were managed in 2017, with treatment area totaling 4.01 infested acres. The higher number of sites visited in 2018 reflects increased efforts toward surveying new areas, some of which had been historically treated by the EPMT within the last decade, but had gone unvisited in recent years.

A total of 26 IEPs were managed in 2018 with manual and chemical control methods at ANP. 21 of these are species of greatest management concern. Five species from our target list are managed at our population goals of either full suppression or reduced below management threshold - Amur maple (*Acer ginnala*), autumn olive (*Elaeagnus umbellata*), burning bush (*Euonymus spp.*), foxglove (*Digitalis purpurea*), and giant hogweed (*Heracleum mantegazzianum*) - whereas most of the remaining species have made progress toward their management goals during 2018. The four-person crew logged over 1,656 hours (with volunteers contributing an additional 54 hours) toward managing IEPs and rehabilitating landscapes. In total, 7.2 gallons of undiluted herbicide were applied in addition to mechanical treatments.

In 2018 the team continued to develop and maintain partnerships with local and state organizations, increased outreach efforts by presenting posters at events, educated interested visitors and local landowners, and maintained commercial pesticide applicator licenses. We continued to collaborate with the Lake Stewards of Maine (LSM; formerly known as the Maine Volunteer Lake Monitoring Program, or VLMP), helping reach the goal of completed surveys for all lakes and ponds on MDI, in which no invasive aquatic plants (IAPs) were found. A joint training on herbicide use and handling was held in collaboration with staff from the Maine Coast Heritage Trust (MCHT) and the Maine Natural Areas Program (MNAP). The EPMT also coordinated a workshop for park employees on tree risk assessment led by U.S. Forest Service staff.

The EPMT continued to maintain native plantings in cultural landscapes at Sieur de Monts, and assisted with a revegetation research project on the Cadillac Mountain summit. The EPMT monitored research transects or plots for glossy buckthorn (*Rhamnus frangula*, syn. *Frangula alnus*), purple loosestrife (*Lythrum salicaria*), and Norway maple (*Acer platanoides*), and assisted visiting scientists in setting up and collecting data for their own experimental vegetation plots. Norway maple management began in earnest with a first round of treatments in January 2018, followed by a larger second round in November, focusing on larger specimens using both cut-stump and hack-and-squirt methods.

Direct program costs for fiscal year 2018 were $295,948. This program is funded primarily through four grants and other “soft” funding sources, including NPS recreational fee revenues, Centennial matching funds (NPS & Donation), and a grant from Canon USA, Inc. procured by Friends of Acadia. This figure includes personal services for the crew and a portion of the park’s Vegetation Program Manager’s salary, as well as supplies, equipment, and limited training and

travel. Maintenance and administrative support, offices, storage, vehicle maintenance, and fuel were funded through other NPS operational funds and are not included in the figure above.
**{Infested acres are defined as total area of leaf canopy cover of invasive plant species at 100% density. In other words, this figure represents the total acreage that would be covered if the entire leaf canopy cover of all treated invasive exotic plants were gathered together at 100% density.}*

Figure 1. Map of locations of invasive exotic plant populations treated or surveyed during the 2018 field season on Mount Desert Island. Treatment and survey efforts of 26 invasive exotic species covered 1,112 acres.

Introduction

Identified as a key issue in Acadia's Foundation Document (2016), nonnative invasive species negatively impact natural and cultural resources. Invasive Exotic Plants (IEPs) are a significant threat to the ecosystems of Acadia National Park (ANP), in particular those lands managed on Mount Desert Island (MDI). These lands have a long history of human disturbance, which increases the likelihood that IEP populations will establish. This area also saw the introduction of horticultural plants that later proved invasive and ecologically damaging. IEPs can degrade or destroy native habitats by displacing the native species that inhabit the area. In extreme cases, IEPs out-compete native plants and form dense monocultures. This has far-reaching consequences for other components of the ecosystem (both flora and fauna) that rely on these native plants for habitat and food. IEPs can also mar views enjoyed by park visitors, damage structures, and degrade cultural resources of the park.

The Acadia National Park Exotic Plant Management Program goals are to:

(1) Preserve healthy habitats using **Early Detection and Rapid Response (EDRR)** to prevent IEP populations from becoming established;
(2) **Manage existing populations** of IEPs to prevent their spread and reduce their populations to thresholds under which they no longer adversely impact native ecosystems (Fully suppressed / Maintenance level); and,
(3) Employ a professional crew that **safely, effectively and efficiently meets the park's exotic plant management needs** using a science-based Integrated Pest Management (IPM) approach.

This document reports all activities related to IEP management for the year 2018. Personnel involved with exotic plant management were Term Biological Technicians Jesse Wheeler, Alexander (Alex) Fetgatter, and Nicholas (Nick) Stevenson, as well as Seasonal Biological Technician James (Jim) Burka.

Goals and Management Objectives

The EPMT's goal regarding established populations of IEPs is to first remove mature, reproductive plants to prevent further seed production (initial attack), and then to reduce the population of all managed IEP species to < 1% total cover of the management unit (suppression; see **Figure 2** below). Once this is achieved, the site is considered below management threshold and will be monitored regularly to determine the need for follow-up, maintenance level treatments, and detection of any new or recurring exotic plant invasions. Ideally, sites at a level below management threshold will be monitored once a year for three years; if IEPs are absent by that point, this will be reduced to once every five years. Although initial treatment efforts can be time- and labor-intensive, once exotic plant populations are significantly reduced the management of low-level populations through cyclic maintenance requires much less investment.

Figure 2. Jim Burka points out glossy buckthorn (*Rhamnus frangula*) seedlings and saplings during second-year follow-up treatment at Kebo Brook, highlighting the importance of revisiting sites after "initial attack." (29 August 2018, NPS Photo)

All management actions (initial treatments, surveys, or re-visits) are logged by hand on standard data sheets that record the following information: treatment location, personnel involved, hours worked, weather, amount and type of herbicide used, and treatment methods, as well as level of infestation and phenology of the exotic species present. All treatment areas are mapped using Global Positioning System (GPS) and Geographic Information System (GIS) technology to record the spatial parameters of the infestation. Photo points (photographs at established locations) are taken pre- and post-treatment whenever possible to help monitor changes in populations over time; some of these points are visited on an annual basis to help gauge long-term population trends.

With many sites and species scattered throughout ANP it is necessary to prioritize which species to treat, and when. To that end we make an effort to manage IEPs in the park by watershed (e.g., Cromwell Brook) or project focus (e.g. Champlain Mountain region). To maintain continuity with past years when naming conventions were not watershed-based, areas within watersheds are further described using historic work location names (e.g., Sieur de Monts, Great Meadow). The IEP populations within these management units and watersheds have been mapped using GPS and GIS; these areas will continue to be surveyed for the presence or absence of targeted IEPs. Management by species and location are reported here to summarize management actions.

Park resource managers have also developed management goals for 25 of the IEP species of greatest concern, including targets for the 2019 field season (see **Table 1** below). Although there are more than 25 IEP species in the park, these particular species were chosen for active management based on species biology and where control is prudent and feasible (NPS Management Policies 4.4.4, 2006). Important management criteria include invasiveness, the threat posed to park resources (i.e., the ecological or cultural values at risk from the plant), and the likelihood of successful management. Much of the inventory work, literature review, and initial prioritization for management in Acadia can be found in the Vegetation Management archives: Reiner and McLendon 2002, Greene et. al. 2004, and Weber and Rooney 2007. The management plans produced from thorough assessment describe species abundance and

distribution within the park, and provide information about habitat, species identification and best management practices. Review of the latest scientific literature and previous management activities are used to update action plans on an annual basis. This ensures they prescribe management strategies based on the latest IPM approaches, with maximum efficacy and minimum toxicity.

All exotic plant management plans and actions are based on the following principals of IPM:

1: Survey the area to identify resources at risk, and determine the location and extent of IEP infestations.
2: Prioritize infestations for management based on threat posed, potential rate of spread, distribution, and feasibility of successful treatment.
3: Review scientific literature and base future management actions on a thorough understanding of IEP biology, treatment alternatives, and potential effects.
4: Consider all available treatment options and select the methods that will most effectively treat the species of concern with the least potential environmental damage.
5: Monitor treated areas to determine treatment success and the need for re-treatment or restoration with native species.
6: Evaluate treatment results and use them to guide future management actions.

Due to the many hazards associated with exotic plant management, as well as the demanding and technical nature of the work, it is of the utmost importance that the park's EPMT be well-trained and professional. To this end crew members and staff all take part in a comprehensive training program, and are licensed by the State of Maine Board of Pesticides Control as Commercial Pesticide Applicators. Program leaders participate in regional professional meetings, such as the Maine Invasive Species Network (MISN) Annual Meeting, to stay abreast of research and improve partnerships and collaboration. Acadia staff also complete mandatory NPS training including personnel management, computer security, hazardous materials communication, and supervision. Field crew training for new staff starts with two weeks of classroom and field training beginning in early May, and is continued throughout the season with frequent safety and IEP species reports and tailgate safety sessions.

Table 1. Management status of invasive exotic plant species in 2018 and 2019 management goals by species for Acadia National Park.

Population Goal	**Level of Effort**	**Targeting Strategy**
Below Management Threshold = Density or cover below Management level threshold (no reproductive plants known, very few immature plants). Not actively managed, incidental only. Monitor sites for species reestablishment.	**High** = crew works on this plant for 100+ person hours/season	**Active** = Management time devoted specifically to this species, usually on an annual or recurring basis. Working toward maintenance level effort.
Fully Suppressed = Known populations are small and very few, contain no known reproductive plants; seed bank may still be viable. Maintenance level effort only.	**Med** = crew works on this plant for 30-100 person hours/season	**Inactive** = Management of species is not targeted due to low priority and/or incomplete management plan.
Nearly Suppressed / Reduced = Known populations small and contain few reproductive individuals; seed bank managed regularly. Recent decrease of treated infested acres.	**Low** = crew works on this plant for 1-30 person hours/season	**Incidental** = Plant managed when encountered during targeted management of other species.
Population Contained = Infested acres remain constant and established populations are prevented from spreading to uninfested areas.	**Maintenance** = New and small recurring populations only. Effort varies between Active (Low) and no treatment per year.	**Rapid Response** = Early detection species actively sought out and managed, if found.
Population Unknown / Increasing = Extent of infestation unknown due to insufficient monitoring efforts or lack of knowledge. Species likely spread over many sites in Acadia.		**Volunteer** = Treatment carried out primarily by volunteers to improve outreach and education or efficiency.

Species (in alphabetical order by common name)	**Years Managed**	**Level of Effort / Targeting Strategy**	**Long-Term Goal**	**Population Status**	**Projected 2019 Effort / Strategy**	**Primary Treatment Method**	**Notes**
Amur maple (*Acer ginnala*)	2006 - 2016	Maintenance / Incidental	Full Suppression	Fully Suppressed	Maintenance / Incidental	Foliar and cut-stump herbicide	Goal currently met
Asiatic bittersweet (*Celastrus orbiculatus*)	2010 - 2018	High / Active	Full Suppression	Population Unknown / Increasing	High / Active	Foliar and cut-stump herbicide	
Autumn olive (*Elaeagnus umbellata*)	2013 - 2018	Low / Rapid Response	Reduce Below Mgmt. Threshold	Below Mgmt. Threshold	Maintenance / Rapid Response	Foliar and cut-stump herbicide	Goal currently met
Barberry (Japanese, common) (*Berberis thunbergii, B. vulgaris*)	2006 - 2018	High / Active	Full Suppression	Population Unknown / Increasing	Med / Active	Foliar herbicide	
Bull thistle (*Cirsium vulgare*)	2013 - 2018	Low / Active	Reduce Below Mgmt. Threshold	Population Unknown / Increasing	Low / Active	Hand pull	Hand pull second year, flowering stems; outer island population status unknown
Burning bush (*Euonymus spp.*)	2011 - 2018	Low / Rapid Response	Reduce Below Mgmt. Threshold	Fully Suppressed	Maintenance / Rapid Response	Foliar and cut-stump herbicide	
Canada thistle (*Cirsium arvense*)	2011 - 2018	High / Active	Reduce Below Mgmt. Threshold	Population Unknown / Increasing	High / Active	Foliar herbicide	
Coltsfoot (*Tussilago farfara*)	2002 - 2018	Low / Incidental	Population Contained	Population Unknown / Increasing	Low / Incidental	Foliar herbicide	
Common mullein (*Verbascum thapsus*)	2011 - 2018	Low / Incidental	Population Contained	Population Unknown / Increasing	Low / Incidental	Hand Pull	
Common reed (*Phragmites australis*)	2013-2014	Maintenance / Rapid Response	Full Suppression	Not in Park yet	Maintenance / Rapid Response	Foliar herbicide	Two known sites on Mount Desert Island; one in wastewater treatment pools at SERC
European bittercress (*Cardamine impatiens*)	2005 - 2018	Low / Volunteer	Nearly Suppressed / Reduced	Population Unknown / Increasing	Med / Volunteer	Hand pull / foliar herbicide	Started monitoring transects in 2018 at Ledgelawn
Exotic bush honeysuckle species (*Lonicera spp.*)	2003 - 2018	High / Active	Full Suppression	Population Contained	High / Active	Foliar and cut stump herbicide	More of a focus in 2018 compared to 2017; some new sites, some re-visits of old (e.g., Nursery / Sand Beach area)
Foxglove (*Digitalis purpurea*)	2003 - 2018	Maintenance / Rapid Response	Reduce Below Mgmt. Threshold	Fully Suppressed	Maintenance / Rapid Response	Hand pull	

Table 1 (continued). Management status of invasive exotic plant species in 2018 and 2019 management goals by species for Acadia National Park.

Species (in alphabetical order by common name)	Years Managed	Level of Effort / Targeting Strategy	Long-Term Goal	Population Status	Projected 2019 Effort / Strategy	Primary Treatment Method	Notes
Garlic mustard (*Alliaria petiolata*)	2003 - 2018	High / Active	Full Suppression	Nearly Suppressed / Reduced	Med / Active	Hand pull	Decreasing at most sites
Giant hogweed (*Heracleum mantegazzianum*)	2003 - 2018	Low / Rapid Response	Reduce Below Mgmt. Threshold	Fully Suppressed	Low / Rapid Response	Foliar herbicide	
Glossy buckthorn (*Frangula alnus*)	2006 - 2018	High / Active	Nearly Suppressed / Reduced	Population Increasing	High / Active	Foliar and cut stump herbicide	Large number of new sites discovered in 2018; initial attack mostly complete at large sites
Japanese honeysuckle (*Lonicera japonica*)	2012	Inactive / Rapid Response	Reduce Below Mgmt. Threshold	Below Mgmt. Threshold	Inactive / Rapid Response	Foliar herbicide	Goal currently met
Japanese knotweed (*Fallopia japonica*)	2003 - 2018	Med / Active	Full Suppression	Population Contained	Med / Active	Cutting then foliar herbicide	Milestone used in 2018 on trial basis
Lupine (*Lupinus polyphyllus*)	2004 - 2017	Inactive / Volunteer	Population Contained	Population Contained	Low / Volunteer	Seed pod removal; hand-pulling near milkweed	"Contained" means kept from natural areas (i.e., relegated to roadsides, ditches, etc.); goal currently met
Multiflora rose (*Rosa multiflora*)	2006 - 2018	Low / Active	Reduce Below Mgmt. Threshold	Nearly Suppressed / Reduced	Low / Active	Foliar herbicide	
Norway maple (*Acer platanoides*)	2017 - 2018	High / Active	Full Suppression	Population Contained	Med / Active	Cut stump herbicide	
Privet (*Ligustrum spp.*)	2016 - 2018	Med / Active	Full Suppression	Nearly Suppressed / Reduced	Low / Active	Cut stump / foliar herbicide	
Purple loosestrife (*Lythrum salicaria*)	1988 - 2018	Med / Active	Full Suppression	Nearly Suppressed / Reduced	Med / Active	Foliar herbicide and seedhead removal	
Spotted knapweed (*Centaurea stoebe*)	2010 - 2018	Low / Rapid Response	Reduce Below Mgmt. Threshold	Nearly Suppressed / Reduced	Low / Rapid Response	Hand pull / foliar	
Yellow iris (*Iris pseudacorus*)	2003 - 2018	Low / Incidental	Reduce Below Mgmt. Threshold	Population Contained	Low / Active	Seed pod removal and cut stem herbicide	Possible foliar application late summer 2019 and/or cut-stem
Currently Under Review	**Years Managed**	**Level of Effort / Targeting Strategy**	**Long-Term Goal**	**Population Status**	**Projected 2019 Effort / Strategy**	**Primary Treatment Method**	**Notes**
Bittersweet nightshade (*Solanum dulcamara*)	2012 - 2016	Inactive	Under Review	Population Unknown / Increasing	Inactive	Foliar herbicide, hand pulling	
Black locust (*Robinia pseudoacacia*)	2018	Maintenance / Incidental	Under Review	Population Unknown	Inactive	N/A	One specimen treated in Blackwoods, Summer 2018
Forest woodrush (*Luzula luzuloides*)	2011	N/A	Under Review	Population Unknown	Low / Incidental	Foliar herbicide	Treat as found in natural areas for 2019

Table 1 (continued). Management status of invasive exotic plant species in 2018 and 2019 management goals by species for Acadia National Park.

Golden chain tree (*Laburnum* x *watereri*)	2012 - 2018	Low / Incidental	Under Review	Population Contained	Inactive	Cut stump herbicide	Some specimens incidentally cut in 2018: a few during roadside work on Old Farm Rd. and one at Duck Brook
Ninebark (*Physocarpus opulifolius*)	2012	N/A	Under Review	Population Unknown	Inactive	N/A	Many mature specimens found around south end of Tarn in 2018 (likely planted)
Reed canary grass (*Phalaris arundinacea*)	2010	N/A	Under Review	Population Unknown	Inactive	Foliar herbicide	
Shrubby St. John's-wort (*Hypericum prolificum*)	2008 - 2016	Inactive	Under Review	Population Contained	Inactive	Foliar herbicide	Monitor for population expansion outside Great Meadow

Program Accomplishments

In 2018, we actively managed 26 invasive exotic plant (IEP) species with manual and chemical control methods in Acadia National Park. The four-person EPMT logged over 1,656 hours (with volunteers contributing an additional 54 hours) toward managing IEPs and rehabilitating landscapes. Over one-third of this time was spent at four sites (out of 91 sites total): Great Meadow, Canon Brook / Otter Creek, the Nursery, and Compass Harbor. This year the EPMT surveyed a record 1,112 acres for invasive plants across varied terrain.

This year's increase in surveyed acres (up from 936 in 2017) was largely due to increased surveys of new areas, based on either reports from park employees / affiliates or records of historic treatments in the area. Some of these historic sites were found to be free of IEPs, while others had residual populations. Target species at the vast majority of these new sites were glossy buckthorn, Japanese knotweed and Norway maple. Another reason for increased survey acres is the success of initial attack operations in previous years. As a result, more time is available for far-reaching surveys as opposed to being dedicated to slow-moving cut-stump operations in densely populated areas.

Among the 91 sites managed in 2018, a majority of the time and effort was spent on four locations. The two most time-consuming sites (Great Meadow with 263.5 work hours and Canon Brook with 189.7 work hours) primarily involved follow-up work in areas with dense glossy buckthorn populations. Initial attack has been completed in these areas, but much effort is still required to keep these populations suppressed while the seed bank and root reserves exhaust themselves. The third most time-consuming site (the Nursery with 116.3 work hours) involved intense follow-up work for invasive bush honeysuckle populations, most of which had seen initial treatment starting in 2014. Compass Harbor came in fourth with 90.5 work hours, most of which are accounted for by the beginning of active Norway maple management, as well as an extra round of hand-pulling treatments for garlic mustard in May.

Glossy buckthorn remains the park's biggest exotic plant challenge, accounting for just under half our treatment efforts in 2018 (based on treated infested acres; see **Figure 3** below). To get a better idea of the efficacy of glossy buckthorn treatment efforts, in 2017 the EPMT established long-term monitoring transects in the Otter Creek watershed, near Route 3 and the Canon Brook confluence, prior to treatment. Monitoring transects measure buckthorn population density as well as reproductive capability (i.e., presence of fruiting versus non-fruiting individuals per square meter). Initial attack treatment was completed in this area in 2017. 2018 measurements (see **Figure 4** below) show that 2017 initial attack efforts were largely successful. At the beginning of the 2018 growing season the count of fruiting glossy buckthorn stems had decreased from 2017 by an average of 66% across all four transects, and percent cover class had decreased by an average of 21%. This is promising in spite of the fact that non-fruiting stems had increased by an average of 61%, which is to be expected as the seed bank responds to increased sunlight reaching through the much-reduced canopy.

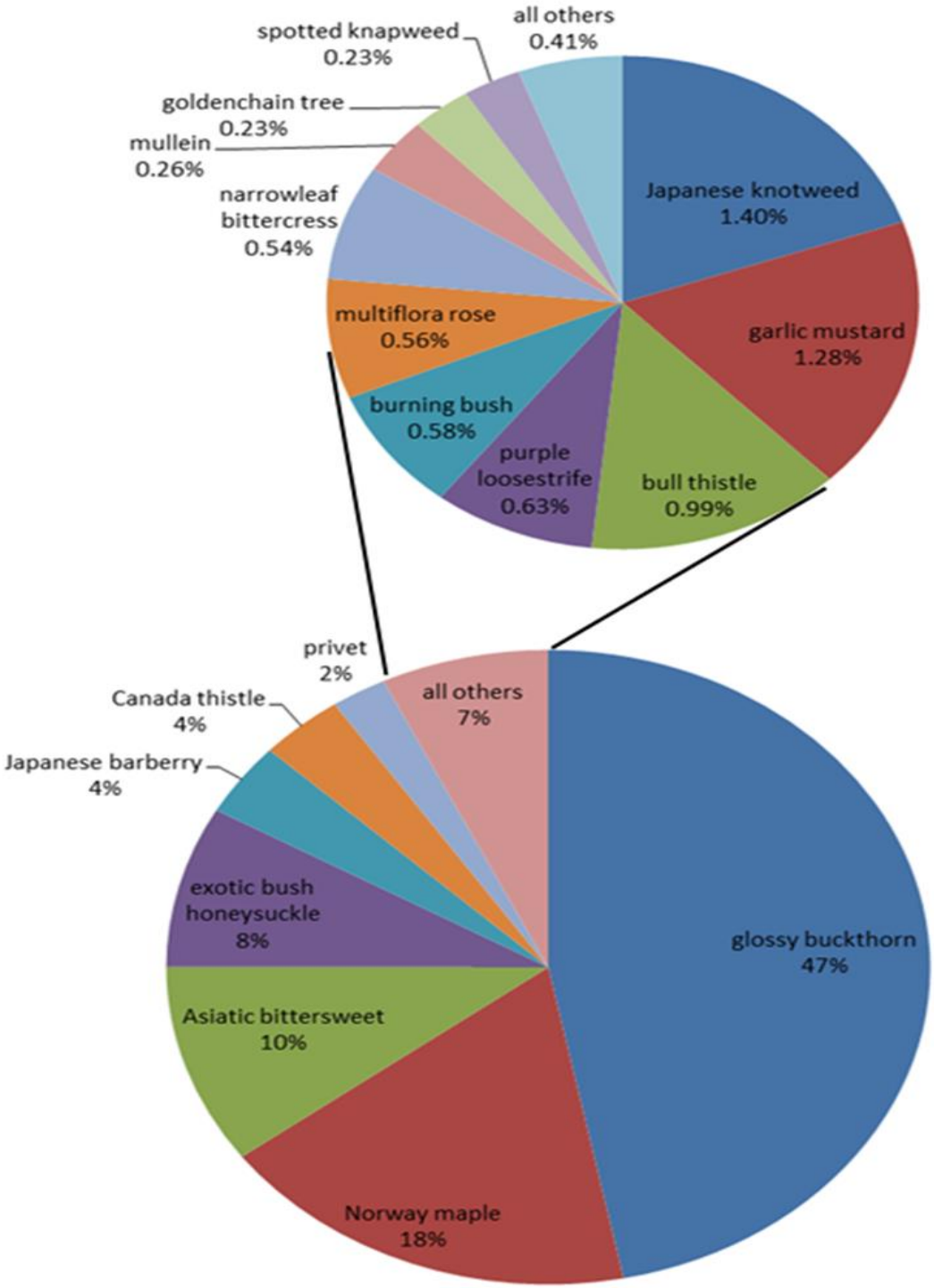

Figure 3. Pie graph of total EPMT treated acres (**3.91 acres**) for all IEPs in 2018. Species grouped together in the "all others" section of the upper graph have treated acre values $\leq$ 0.005 acres. These species include: common barberry, autumn olive, common burdock, coltsfoot, black locust, foxglove, yellow iris, giant hogweed, and dame's rocket.

In 2018 EPMT crew members again worked with Schoodic Institute staff for annual data collection at the ten Norway maple monitoring plots established at Compass Harbor, Duck Brook, and Great Meadow Drive (a.k.a., Ledgelawn Extension). These long-term monitoring plots will help show changes in forest structure over time as Norway maples are systematically removed from the landscape. Average percent canopy openness has increased after the initial wave of treatments in January 2018, which focused in and around the seven treatment plots. Both native and invasive groundcovers (herbs, grasses, shrubs, and vines/lianas) have responded to the increased sunlight, with existing populations increasing in size as well as new populations becoming established. Full suppression of Norway maple in Acadia is a goal that will be a long-term process. In November 2018 the EPMT completed a second round of treatments, focusing on areas with smaller Norway maple populations in an effort to narrow the treatment focus to the more dense areas in and around downtown Bar Harbor in ensuing years.

Figure 4. EPMT Program Coordinator Jesse Wheeler collects glossy buckthorn population data along Transect 4 near the confluence of Canon Brook and Otter Creek, 10 July 2018. NPS Photo

The EPMT increased control efforts for Japanese knotweed yet again in 2018, treating three more sites than in 2017 (a total of 25 in 2018 versus 22 in 2017). The bamboo-like plant will grow to 10 feet tall in one season, often forming dense stands that crowd out scenic views and native plants. A majority of sites are along road shoulders where the plant can spread via roots and tiny plant fragments transported in construction fill and via snow plows. Multiple treatments over several years are needed to fully suppress Japanese knotweed; this means 2019 and beyond could require increased effort, especially if new locations keep getting discovered. In addition to

the increased number of sites, a new method was also tested for Japanese knotweed treatments in 2018. Some sites were foliar treated with the traditional 5% Rodeo historically used by the EPMT, while others were sprayed with 0.4% Milestone. Follow-up monitoring visits in 2019 will show whether or not this new treatment is as effective as the old.

We formalized the evaluation of treatment efficacy during follow-up site visits in 2018. Datasheets were created to record the following information: location, monitor date, treatment date, original species treated, treatment method, percent killed, retreatment (if applicable), other species observed, and future recommendations. This will help document progress in reducing invasive plant populations, as well as inform future treatment decisions as part of an adaptive management strategy.

Throughout 2018 the team continued to develop and maintain partnerships with local and state organizations including Friends of Acadia, Mount Desert Land & Garden Preserve, Somes-Meynell Wildlife Sanctuary, Maine Coast Heritage Trust, Maine Department of Agriculture, Conservation and Forestry (including both Maine Forest Service and Maine Natural Areas Program), US Forest Service, and Lake Stewards of Maine (LSM; formerly known as Maine Volunteer Lake Monitoring Program, or VLMP). Vegetation staff also attended the Maine Invasive Species Network (MISN) Annual Meeting to discuss current invasive species threats to the State, earning continuing education credits to maintain Commercial Pesticide Applicator licenses in the process. The team increased outreach efforts by presenting posters on exotic plant management techniques at both the MISN Annual Meeting and College of the Atlantic's (CoA) Acadia Science Symposium. Team members participated in local community outreach efforts by presenting to the Mount Desert Garden Club, leading educational field trips for CoA classes at Sieur de Monts, and meeting with landscape managers at the Mount Desert Land & Garden Preserve to discuss invasive plant management strategies on their neighboring properties near Seal Harbor.

Exotic plant management field operations ran until December 4, 2018. This is roughly one-and-a-half months longer than in previous years, thanks to the new Norway maple initial attack treatment efforts which can occur even after leaf senescence. Afterward Alex and Nick continued field work in a different capacity by aiding the Maintenance Division in clearing trees and other woody vegetation from rights-of-way and drainage ditches along carriage roads (particularly Day Mountain), as well as clearing hazard trees and roadside vegetation along motor roads. Assisting tree-felling operations, they made cut-stump herbicide treatments to prevent deciduous trees from stump sprouting, looked for woody invasive plants, and provided on-site plant identification to the roads crew.

Invasive Exotic Plant Species of Greatest Concern Managed in 2018

A total of 3.92 infested acres were managed on NPS and adjacent private lands with written permission of landowners. Of these, six of the most heavily managed species are highlighted in **Table 2** below: garlic mustard, Japanese barberry, glossy buckthorn, Japanese knotweed, bush honeysuckle, and Asiatic bittersweet. Several other IEPs are less widespread and either fall

below ecological impact thresholds and are thus managed incidentally, or are managed at single locations with less coverage in the park (see **Table 3** below).

Table 2. 2018 surveyed and infested acres of invasive plants by species managed to significantly reduce populations in designated treatment areas (Population Reduced, Nearly Suppressed or Contained).

Species	Site / Location	Surveyed Acres	Infested Acres
garlic mustard (*Alliaria petiolata*)	Bass Harbor	0.81	0.00625
	Compass Harbor	16.44	0.04008
	Fernald Point	0.42	0.000063
	Headquarters	2.51	0.000163
	Holy Redeemer Cemetery	0.64	0.00002
	Jordan Pond Carriage Road	1.09	0.000916
	Jordan Pond Rd. Erosion Site	0.91	0.000118
	Ledgelawn	9.63	0.001659
	Nursery	3.36	0.000081
	Otter Cliffs Road	1.96	0.000436
	Otter Cove	1.06	0.000092
	Seawall	0.8	0.000128
Herbicide concentrate used:	Thailand	0.71	0.000016
None (manual control)	**Total**	**40.34**	**0.050022**
Japanese barberry (*Berberis thunbergii*)	Around Mountain	0.57	0.000714
	Bar Island	27.38	0.025909
	Bass Harbor	8.57	0.036089
	Blackwoods	1.72	0.000039
	Breakneck Brook	16.32	0.004844
	Canon Brook	28.06	0.004386
	Cleftstone	8.16	0.000247
	Compass Harbor	0.09	0.000016
	Day Mountain Carriage Road	0.01	0.000078
	Dorr Mountain South	7.08	0.000272
	Duck Brook	20.94	0.028196
	Duck Brook Road Wetland	4.66	0.000101
	Eagle Lake	0.79	0.000039
	Fernald Point	4.8	0.003098
	Frazer Point	14.32	0.000492
	Great Meadow	6.03	0.000171
	Harden Farm	11.42	0.000683
	Headquarters	4.24	0.00007
	Hulls Cove House	2.04	0.000613
	Isle au Haut	24.54	0.010427
	Jordan Pond House	0.36	0.000004
	Jordan Pond Rd. Erosion Site	0.84	0.000047
	Kebo Brook	15.55	0.001088
	Kent Field South	5.53	0.000217
	Ledgelawn	2.87	0.000031
	Liscomb Pit	5.78	0.000698
	Lower Mountain Road	3.47	0.000854
	Man of War Rd.	0.67	0.000574
	Marshall Brook	23.41	0.002477

Table 2 (continued). 2018 surveyed and infested acres of invasive plants by species managed to significantly reduce populations in designated treatment areas.

Species	Site / Location	Surveyed Acres	Infested Acres
Japanese barberry (continued)	McFarland Hill	1.41	0.000054
	Motor Road Vista #57	0.53	0.000039
	New Mills Meadow	1.91	0.001436
	Nursery	19.16	0.003984
	Otter Cove	3.18	0.000233
	Otter Cove Boat Launch	10.20	0.002104
	Paradise Hill	14.72	0.00465
	Route 3 / Tarn	1.67	0.000388
	Sand Beach	2.22	0.001879
	Satterlee Pit	2.13	0.000116
	Sawyer's Point	6.22	0.000194
	Seal Cove Road	27.73	0.001017
	Sheep Porcupine Island	8.43	0.001012
	Sieur de Monts	0.24	0.000233
	Thailand	0.53	0.000062
	Thompson Island	6.01	0.000264
	Tremont School	1.99	0.000078
	Valley Cove	2.2	0.001405
	Visitor Center	3.66	0.000232
	Western Mountain Road	1.37	0.000155
Herbicide concentrate used:	White Birches Campground	3.76	0.000512
Rodeo: 60.69 oz.	Wildwood Stables	14.09	0.001996
Garlon 4 Ultra: 1.08 oz.	Witch Hole	3.61	0.00191
Milestone: 0.03 oz.	**Total**	**387.19**	**0.146427**
glossy buckthorn (*Rhamnus frangula*)	Bear Brook	7.42	0.03314
	Beaver Dam Pond	3.89	0.003478
	Brown Mountain Gatehouse	0.56	0.000039
	Cadillac Mountain Entrance	2.56	0.026014
	Cadillac Mountain Road	2.498	0.002339
	Canon Brook	68	0.603365
	Compass Harbor	3.39	0.001331
	Dorr Mountain South	7.08	0.002275
	Duck Brook Road Wetland	4.66	0.022276
	Eagle Lake	12.92	0.001289
	Enoch Mountain	3.58	0.003983
	Flying Mountain Parking	1.77	0.000016
	Frazer Point	7.49	0.000068
	Furnace	2.79	0.000023
	Great Meadow	74.11	0.646101
	Harden Farm	26.69	0.086005
	Headquarters	4.24	0.000256
	Jordan Pond House	0.55	0.00007
	Jordan Stream	17.69	0.000094
	Kebo Brook	17.2	0.042248
	Kent Field Central	2.56	0.001337
	Kent Field North	9.68	0.089575
	Kent Field South	0.32	0.001918
	Ledgelawn	6.07	0.067257

Table 2 (continued). 2018 surveyed and infested acres of invasive plants by species managed to significantly reduce populations in designated treatment areas.

Species	Site / Location	Surveyed Acres	Infested Acres
glossy buckthorn (continued)	Little Harbor Brook	10.59	0.001592
	Lower Hadlock Pond	7.27	0.009014
	Marshall Brook	28.25	0.002103
	McFarland Hill	6.31	0.002506
	Motor Road Vista #57	0.53	0.001141
	New Mills Meadow	3.83	0.000691
	Nursery	19.89	0.000737
	Otter Cove Boat Launch	11.17	0.001607
	Paradise Hill	3.68	0.000016
	Route 233 / 198 Intersection	0.96	0.00024
	Route 3 / Tarn	11.38	0.072491
	Sand Beach	3.03	0.000004
	Satterlee Pit	2.38	0.001739
	Sawyer's Point	6.22	0.001747
	Schooner Head	2.53	0.000016
	Seal Cove Road	29.74	0.099664
	Ship Harbor	0.63	0.0001
	Shooting Range	3.05	0.000016
Herbicide concentrate used:	Sieur de Monts	0.97	0.000879
Rodeo: 574.40 oz.	Stanley Brook	0.36	0.000973
Garlon 3A: 1.15 oz.	Tremont School	1.99	0.000412
Garlon 4 Ultra: 1.08 oz.	White Birches Campground	3.1	0.000031
Pathfinder II: 0.3 oz.	Wildwood Stables	7.63	0.00014
	Total	**453.208**	**1.832356**
Japanese knotweed (*Fallopia japonica*)	Blackwoods	4.1	0.000815
	Bubble Pond	0.96	0.000683
	Bubble Rock Parking Lot	0.17	0.000443
	Cadillac Mountain Entrance	1.14	0.00002
	Cadillac Mountain Road	0.39	0.000032
	Compass Harbor	9.33	0.02023
	Eagle Lake	0.69	0.000916
	Echo Lake	1.79	0.004445
	Headquarters	0.15	0.000248
	Holy Redeemer Cemetery	0.74	0.000217
	Hulls Cove House	1.94	0.000249
	Jordan Pond Rd. Erosion Site	0.97	0.000435
	Ledgelawn	4.08	0.000276
	McFarland Hill	0.35	0.000093
	Otter Cove Boat Launch	10.2	0.000085
	Route 198	37.76	0.001343
	Route 233 / 198 Intersection	2.24	0.001363
	Route 3 / Tarn	0.4	0.000373
	Satterlee Pit	0.87	0.002817
	Shooting Range	2.24	0.001096
	Sieur de Monts	0.65	0.000024
	Start of One-way (PLR)	0.36	0.000085
Herbicide concentrate used:	Thailand	2.78	0.00143
Rodeo: 1.13 oz.	Thompson Island	0.97	0.015953
Milestone: 0.93 oz.	White Birches Campground	5.82	0.001048
	Total	**91.09**	**0.054719**

Table 2 (continued). 2018 surveyed and infested acres of invasive plants by species managed to significantly reduce populations in designated treatment areas.

Species	Site / Location	Surveyed Acres	Infested Acres
exotic bush honeysuckle (*Lonicera* spp.)	Bar Island	23.88	0.001908
	Bass Harbor	3.78	0.003377
	Bear Brook	0.4	0.000505
	Brown Mountain Gatehouse	1.6	0.002841
	Cadillac Mountain Entrance	0.94	0.001211
	Cadillac Mountain Road	0.53	0.004788
	Canon Brook	33.73	0.005232
	Cleftstone	1.96	0.000265
	Compass Harbor	5.42	0.000024
	Day Mountain Carriage Road	0.54	0.000194
	Duck Brook	19.97	0.001235
	Eagle Lake	0.79	0.000039
	Enoch Mountain	6.4	0.00083
	Fabbri Memorial	0.45	0.000272
	Fernald Point	4.8	0.000758
	Flying Mountain Parking	1.77	0.000729
	Frazer Point	14.32	0.00096
	Furnace	2.79	0.002698
	Great Meadow	30.45	0.000637
	Harden Farm	9.19	0.002779
	Headquarters	5.09	0.00049
	Hulls Cove House	1.18	0.000334
	Jordan Cliffs	10.52	0.000039
	Jordan Pond House	0.36	0.000047
	Jordan Pond Road Erosion Site	0.97	0.000776
	Kebo Brook	11.18	0.000016
	Kent Field South	5.29	0.000047
	Ledgelawn	6.07	0.002437
	Lower Hadlock Pond	1.35	0.000023
	McFarland Hill	1.41	0.000093
	Motor Road Vista #57	0.53	0.001203
	New Mills Meadow	4.66	0.017188
	Nursery	34.78	0.064143
	Otter Cliffs Road	3.66	0.001677
	Otter Cove	3.18	0.002236
	Otter Cove Boat Launch	11.17	0.027445
	Paradise Hill	15.55	0.003563
	Pooler Farm	2.56	0.000388
	Pretty Marsh	1.69	0.000295
	Route 233 / 198 Intersection	0.96	0.000008
	Route 3 / Tarn	7.77	0.001171
	Sand Beach	5.42	0.026629
	Satterlee Pit	5.47	0.002981
	Schoodic Peninsula	85.95	0.020965
	Schooner Head	2.53	0.000217
	Seal Cove Road	27.15	0.00133
	Seawall	0.94	0.000729
	Sheep Porcupine Island	8.43	0.028851
	Shooting Range	4.65	0.001224
	Sieur de Monts	0.62	0.000023

Table 2 (continued). 2018 surveyed and infested acres of invasive plants by species managed to significantly reduce populations in designated treatment areas.

Species	Site / Location	Surveyed Acres	Infested Acres
exotic bush honeysuckle (continued)	Stanley Brook	4.2	0.000271
	Thailand	0.46	0.000091
	The Hop	6.06	0.074968
Herbicide concentrate used:	Thompson Island	9	0.002151
Rodeo: 96.27 oz.	Tremont School	1.99	0.000388
Garlon 4 Ultra: 8.03 oz.	Upper Hadlock Pond	0.8	0.000148
Garlon 3A: 4.00 oz.	White Birches Campground	4.8	0.015836
Milestone: 1.18 oz.	Witch Hole	0.06	0.000311
	Total	**462.17**	**0.332014**
Asiatic bittersweet (*Celastrus orbiculatus*)	Amphitheater	0.48	0.000125
	Bar Island	18.1	0.002187
	Bass Harbor	4.79	0.002445
	Bear Brook	7.02	0.005358
	Brown Mountain Gatehouse	0.56	0.000023
	Cadillac Mountain Entrance	1.15	0.000016
	Canon Brook	22	0.000583
	Cleftstone	1.96	0.000791
	Compass Harbor	2.59	0.000132
	Duck Brook	8.97	0.000202
	Duck Brook Road Wetland	1.54	0.000031
	Fernald Point	4.8	0.000571
	Flying Mtn. Parking Lot	1.96	0.001513
	Frazer Point	14.3	0.001046
	Furnace	2.79	0.000004
	Great Meadow	29.4	0.000413
	Harden Farm	24.8	0.003385
	Headquarters	4.01	0.000396
	Hulls Cove House	1.18	0.007821
	Jordan Cliffs	10.91	0.000031
	Jordan Pond Carriage Road	16.93	0.182177
	Jordan Pond House	1.93	0.005186
	Kent Field North	10.4	0.000636
	Ledgelawn	3.2	0.002227
	Lower Hadlock Pond	1.35	0.000078
	McFarland Hill	3.4	0.002463
	Motor Road Vista #57	0.53	0.001396
	Nursery	30.8	0.090798
	Otter Cliffs Road	2.7	0.000846
	Otter Cove	3.18	0.00014
	Otter Cove Boat Launch	11.17	0.002422
	Paradise Hill	6.35	0.010872
	Pretty Marsh	1.69	0.000037
	Route 198	2.36	0.00041
	Route 233 / 198 Intersection	0.96	0.000047
	Route 3 / Tarn	2.24	0.000167
	Sand Beach	5.25	0.001113
	Satterlee Pit	3.34	0.000326
	Sawyer's Point	19.04	0.015756
	Seal Cove Road	25.14	0.001588

Table 2 (continued). 2018 surveyed and infested acres of invasive plants by species managed to significantly reduce populations in designated treatment areas.

Species	Site / Location	Surveyed Acres	Infested Acres
Asiatic bittersweet (continued)	Seawall	0.94	0.013139
	Sheep Porcupine Island	8.43	0.000419
	Sieur de Monts	1.63	0.000489
	Stanley Brook	4.2	0.000812
	Thailand	1.86	0.011535
	The Hop	2.98	0.000644
	Thompson Island	9.67	0.01589
Herbicide concentrate used:	Upper Hadlock Pond	0.8	0.008504
Rodeo: 42.42 oz.	Visitor Center	3.31	0.000714
Garlon 3A: 18.05 oz.	White Birches Campground	4.8	0.001164
Milestone: 0.14 oz.	Wildwood	7.63	0.000241
	Total	**361.52**	**0.399309**

Table 3. 2018 surveyed and infested acres of invasive plants by species managed below ecological impact thresholds (Fully or Nearly Suppressed - Maintenance level; listed in alphabetical order by scientific name). Some of these require only incidental management, meaning surveys are not conducted specifically for these species; rather they are treated as encountered on a case-by-case basis.

Species	Site / Location	Surveyed Acres	Infested Acres
Amur maple (*Acer ginnala*)*	no treatment in 2018	n/a	n/a
common burdock (*Arctium minus*)*	Cadillac Mountain Road	0.02	0.000272
	Eagle Lake	1.44	0.000194
	Great Meadow	6.03	0.000155
	Headquarters	0.65	0.000776
	New Mills Meadow	0.16	0.000194
	Otter Cove	3.18	0.000116
	Satterlee Pit	3.34	0.000994
Herbicide concentrate used:	Schoodic Campus	5.99	0.00066
None (manual control)	**Total**	**20.81**	**0.003361**
common barberry (*Berberis vulgaris*)*	Fernald Point	0.41	0.001009
	Great Meadow	5.39	0.000039
	Jordan Pond Carriage Road	1.24	0.001988
Herbicide concentrate used:	Nursery	6.98	0.001382
Rodeo: 0.66 oz.	Wildwood	6.46	0.000233
Garlon 4 Ultra: 0.13 oz.	**Total**	**20.48**	**0.004651**
narrowleaf bittercress (*Cardamine impatiens*)*	Bar Island	22.21	0.000582
	Bass Harbor	0.31	0.00755
	Compass Harbor	2.83	0.000078
	Harden Farm	6.43	0.000019

Table 3 (continued). 2018 surveyed and infested acres of invasive plants by species managed below ecological impact thresholds.

Species	Site / Location	Surveyed Acres	Infested Acres
narrowleaf bittercress (continued)	Jordan Pond Carriage Road	0.38	0.000016
	Ledgelawn	2.91	0.012363
	Nursery	14.56	0.000222
Herbicide concentrate used:	Otter Cliffs Road	1.21	0.000222
Rodeo: 4.69 oz.	**Total**	**50.84**	**0.021052**
Canada thistle (*Cirsium arvense*)	Baker Island	13.01	0.091221
	Bar Island	1.79	0.001219
	Bear Brook	2.32	0.000233
	Breakneck Brook	6.73	0.000155
	Bubble Pond	0.45	0.00007
	Bubble Rock	0.31	0.000357
	Canon Brook	1.1	0.000745
	Duck Brook	0.34	0.000023
	Fabbri Memorial	0.27	0.000078
	Frazer Point	6.83	0.001421
	Great Meadow	3.06	0.000322
	Hulls Cove House	1.18	0.000217
	Isle au Haut	32.12	0.019433
	Jordan Pond House	0.16	0.001056
	Kent Field North	1.6	0.000031
	New Mills Meadow	1.75	0.000652
	Nursery	3.95	0.000365
	Otter Cove	3.18	0.002556
	Pooler Farm	2.56	0.000155
	Sand Beach	3.03	0.00111
	Satterlee Pit	3.34	0.000318
	Sawyer's Point	0.68	0.000155
	Schoodic Campus	5.99	0.000378
	Schoodic Island	10.41	0.003214
	Schoodic Peninsula	41.1	0.000163
	Seawall	3.06	0.011361
	Ship Harbor	0.63	0.000039
	Shooting Range	4.01	0.000117
	Sieur de Monts	2.63	0.000776
	Thailand	0.09	0.00007
	The Hop	2.98	0.000016
	Thompson Island	6.01	0.000016
Herbicide concentrate used:	Tremont School	1.99	0.000295
Milestone: 3.98 oz.	Wildwood	7.63	0.000047
Rodeo: 0.12 oz.	Wonderland	0.69	0.000932
	Total	**176.98**	**0.139316**

Table 3 (continued). 2018 surveyed and infested acres of invasive plants by species managed below ecological impact thresholds.

Species	Site / Location	Surveyed Acres	Infested Acres
bull thistle (*Cirsium vulgare*)	Baker Island	13.01	0.02398
	Bar Island	4.32	0.000827
	Bear Brook	8.42	0.001016
	Breakneck Brook	6.73	0.000023
	Compass Harbor	4.83	0.000155
	Fernald Point	0.5	0.000349
	Headquarters	1.19	0.001359
	Hulls Cove House	1.18	0.000062
	Isle au Haut	34.71	0.00687
	Kent Field North	0.28	0.00007
	Liscomb Pit	1.48	0.00007
	Marshall Brook	7.91	0.000039
	New Mills Meadow	1.75	0.000241
	Route 198	2.36	0.000016
	Sand Beach	3.03	0.000008
	Satterlee Pit	5.47	0.000699
	Schoodic Campus	5.99	0.000155
	Schoodic Island	10.41	0.001289
	Seawall	1.87	0.00007
	Shooting Range	2.41	0.000388
	The Hop	6.06	0.000125
	Thompson Island	6.01	0.000039
	Tremont School	1.99	0.000008
Herbicide concentrate used:	Visitor Center	3.31	0.000085
Rodeo: 0.71 oz.	Wildwood	7.63	0.000857
Milestone: 0.47 oz.	Wonderland	0.69	0.000078
	Total	**143.54**	**0.038878**
autumn olive (*Elaeagnus umbellata*)*	Eagle Lake	0.07	0.00014
Herbicide concentrate used:	Otter Cove Boat Launch	1.48	0.003913
Rodeo: 0.13 oz.	**Total**	**1.55**	**0.004053**
Garlon 4 Ultra: 0.02 oz.			
burning bush (*Euonymus alatus*)*	Paradise Hill	5.52	0.020211
Herbicide concentrate used:	Thailand	0.46	0.002444
Rodeo: 1.71 oz.	**Total**	**5.98**	**0.022655**
Garlon 4 Ultra: 0.90 oz.			
giant hogweed (*Heracleum mantegazzianum*)	Stanley Brook	3.84	0.000136
Herbicide concentrate used:	**Total**	**3.84**	**0.000136**
Rodeo: 0.03 oz.			
shrubby St. John's-wort (*Hypericum prolificum*)*	no treatment in 2018	n/a	n/a
yellow iris (*Iris pseudacorus*)	Satterlee Pit	2.13	0.00014
Herbicide concentrate used:	**Total**	**2.13**	**0.00014**
None (manual control – deadheading)			

Table 3 (continued). 2018 surveyed and infested acres of invasive plants by species managed below ecological impact thresholds.

Species	Site / Location	Surveyed Acres	Infested Acres
privet (*Ligustrum spp.*)	Bar Island	27.38	0.087255
	Brown Mountain Gatehouse	1.04	0.000139
	Cleftstone	0.88	0.001025
	Compass Harbor	2.83	0.000062
	Furnace	2.81	0.000004
	Hulls Cove House	1.18	0.000078
	Ledgelawn	2.87	0.000466
	Otter Cove Boat Launch	10.20	0.000085
	Paradise Hill	2.85	0.000194
	Seal Cove Road	25.14	0.000613
Herbicide concentrate used:	Sheep Porcupine Island	8.43	0.000016
Rodeo: 45.45 oz.	Stanley Brook	0.36	0.000077
Garlon 4 Ultra: 0.80 oz.	Thailand	0.99	0.000295
Garlon 3A: 0.03 oz.	The Hop	2.98	0.001397
	Total	**89.94**	**0.091706**
lupine (*Lupinus polyphyllus*)	no treatment in 2018	n/a	n/a
purple loosestrife (*Lythrum salicaria*)	Bear Brook	7.02	0.000575
	Beaver Dam Pond	3.89	0.000295
	Compass Harbor	1.87	0.001964
	Duck Brook Road Wetland	3.12	0.000078
	Eagle Lake	1.44	0.000031
	Great Meadow	5.01	0.000023
	Hulls Cove House	3.1	0.000035
	Kent Field Central	2.56	0.001602
	Kent Field North	6.93	0.000543
	Liscomb Pit	1.48	0.000023
	Marshall Brook	12.45	0.019122
Herbicide concentrate used:	Route 3 / Tarn	1.4	0.000085
Rodeo: 7.20 oz.	Satterlee Pit	2.13	0.000272
	Total	**52.4**	**0.024648**
bittersweet nightshade (*Solanum dulcamara*)*	no treatment in 2018	n/a	n/a
multiflora rose (*Rosa multiflora*)*	Duck Brook	8.97	0.000039
	Hulls Cove House	1.18	0.000047
	Jordan Pond Rd. Erosion Site	0.41	0.000349
	Kebo Brook	1.65	0.000132
	Ledgelawn	2.91	0.000264
	Marshall Brook	7.91	0.000411
	New Mills Meadow	0.16	0.000388
	Otter Cove Boat Launch	11.17	0.001266

Table 3 (continued). 2018 surveyed and infested acres of invasive plants by species managed below ecological impact thresholds.

Species	Site / Location	Surveyed Acres	Infested Acres
multiflora rose (continued)	Paradise Hill	14.72	0.001124
	Sawyer's Point	0.68	0.000311
	Seal Cove Road	27.73	0.00132
Herbicide concentrate used:	Shooting Range	1.6	0.001467
Rodeo: 8.55 oz.	White Birches Campground	4.8	0.014657
Garlon 4 Ultra: 1.38 oz.	**Total**	**83.89**	**0.021775**
coltsfoot (*Tussilago farfara*)*	Blackwoods	33.02	0.000218
	Breakneck Brook	6.73	0.000257
	Bubble Pond	0.62	0.000078
	Canon Brook	3.68	0.000093
	Day Mountain Carriage Road	0.89	0.000008
	Jordan Cliffs	10.52	0.000055
	Little Harbor Brook	10.59	0.000078
	Otter Cliffs Road	0.32	0.000012
	Route 198	2.36	0.000031
	Schoodic Campus	5.99	0.000543
Herbicide concentrate used:	Schoodic Peninsula	127.05	0.000316
Rodeo: 0.27 oz.	Thompson Island	6.01	0.000932
Garlon 3A: 0.03 oz.	**Total**	**207.78**	**0.002621**
mullein (*Verbascum thapsus*)*	Bar Island	15.57	0.002635
	Headquarters	0.65	0.000116
	Isle au Haut	22.75	0.001763
	Liscomb Pit	1.48	0.000039
	Sand Beach	3.03	0.000699
	Satterlee Pit	3.34	0.001087
	Sawyer's Point	0.16	0.000078
	Schoodic Campus	5.99	0.000272
	Schoodic Peninsula	41.1	0.000124
	Seal Cove Road	25.14	0.000233
	Seawall	3.06	0.000178
	The Hop	6.06	0.002862
Herbicide concentrate used:	Thompson Island	2.81	0.00007
None (manual control)	Wildwood	7.63	0.00007
	Total	**138.77**	**0.01035**

** indicates this species is treated incidentally, meaning it is treated when encountered but is generally not specifically searched / scouted for.*

Management Activities by Species

Garlic Mustard

Garlic mustard (*Alliaria petiolata*) has been managed by hand-pulling since the mid-2000s, and most of the park's sites are small and can be treated quickly. In 2018 sites were visited three times, with the goal of eradicating the smaller populations. The EPMT also visited each historic site treated back to 2009 and found garlic mustard in two locations not recently visited: Headquarters and the Nursery. Some attempts were also made to check other species at historic treatment locations. These re-visits only included historic treatments from the past few years however; re-visits should be expanded in 2019 to cover more historic sites from even earlier years.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*) management continued in 11 wetland sites throughout ANP, including three new locations at Eagle Lake parking along Route 233, Liscomb Pit and Great Meadow. All of these new sites were marked by a single flowering stem where a rapid response hopefully stopped the infestations from spreading. The park's wildlife crew found one flowering stem along the banks of Cromwell Brook in the middle of Great Meadow while conducting beaver surveys by canoe, signifying the importance of surveying wetland areas that are difficult to access. An increase in treatments within wetlands that have historically had purple loosestrife, but that haven't been treated in several years, resulted in more locations managed in 2018 over 2017 (11 sites in 2018 versus 7 sites in 2017). Marshall Brook and Beaver Dam Pond continue to be the two sites in the Park where a modest number of blooming plants are still found, albeit in far fewer numbers compared to previous years. The EPMT surveyed and treated over 12 acres in Marshall Brook and 4 acres around Beaver Dam Pond.

The EPMT revisited long-term loosestrife monitoring transects at the Tarn, around Beaver Dam Pond, and Bear Brook in 2018. Starting in 1989, resource managers recorded the density of flowering and vegetative stems using these monitoring transects. In 2018 we encountered no flowering or vegetative stems at the Tarn or Beaver Dam Pond, but we did find purple loosestrife in a monitoring transect at Grids 6 and 7 near Bear Brook.

The one meter wide transects were measured up to 50m, or until open water was encountered. We did not find any flowering purple loosestrife in either 2017 (Transect 1) or 2018 (Transect 2). We only found vegetative stems in Grids 6 and 7 at Bear Brook in both 2017 and 2018. At a glance, reproductive and flowering stems have remained low in monitoring transects over the years, with the majority being observed in Grid 7 at Bear Brook (**Figure 5**). Over time, flowering stems have been reduced and kept in check, but recent monitoring has shown a slight increase in vegetative stems at this location. This result could be due to a persistent seed bank that continues to germinate new shoots each year. There may also be soil disturbance from flooding and animal activity that enables new seed to come in and germinate. It will be important to keep visiting this site every year and treating any stems that do show up.

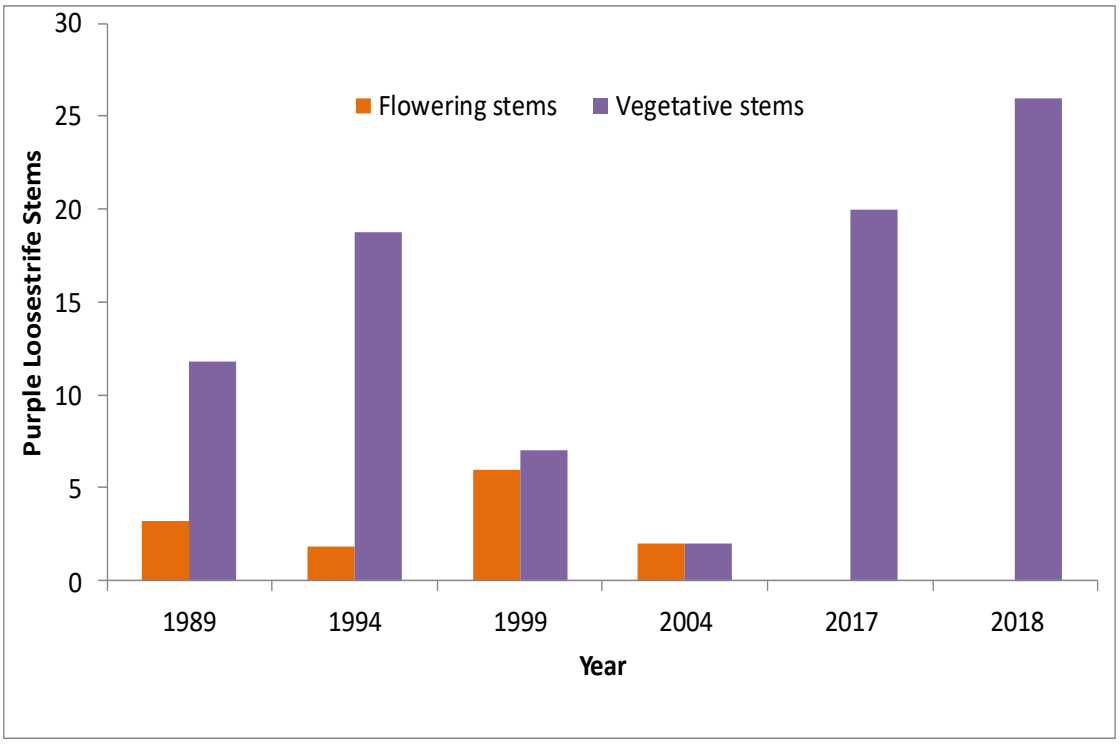

Figure 5. Flowering and vegetative stems of purple loosestrife in monitoring Grid 7 at Bear Brook, Acadia National Park. All transects sampled in 1989 and 1994, figure numbers represent average per transect. Only Transect 5 was sampled in 1999 and 2004. Transect 1 sampled in 2017 and Transect 2 sampled in 2018.

Purple loosestrife management in Acadia continues to operate at modest levels. Annual time investments range between 30-100 person hours, where most of this time is spent scouting wetlands for the signature purple flower. Scouting is scheduled for late July to early August to ensure flowers are at their peak, and thus most visible from long distances. Infested acres remain low at "Nearly Suppressed / Reduced" levels, where control efforts are limited to a few flowering plants and some emerging new plants from the extant seed bank.

Japanese Barberry

Scouting and treatment of Japanese barberry (*Berberis thunbergii*) continued throughout the 2018 field season, with a concerted effort in late April / early May when barberry is most visible due to its early leaf-out relative to most other surrounding woody vegetation. Some new areas were explored, including a couple streambeds east of Lower Mountain Road and south of the Cadillac Summit Road, and some old home foundations at the beginning of the access road to the Bass Harbor Head Lighthouse (intersection of Lighthouse Road and Route 102A / Harbor Drive). These new areas were prioritized based on reports of barberry populations from other park employees or affiliates, as well as in-field observations by EPMT members.

Other areas were revisited to check on treatment efficacy from previous years, including Bar Island (see **Figure 6** below), Wildwood Stables, Breakneck Brook (particularly the inflow wetland on the southern end of the old beaver pond near the Hulls Cove Visitor Center), and parts of Paradise Hill. Of special note are the specimens on the northern half of Bar Island, nearly all of which were treated with foliar herbicide applications in the spring of 2016. On revisiting these it was found that some individuals were still alive, albeit with reduced leaf cover. Some specimens had retained as much as 50% of their leaf output potential. It is unknown at this time what caused the ineffective treatment. Possibilities include the use of old herbicide that may have been less effective, treatment too early when leaves were not fully grown, cold temperatures at the time of application, or rainfall shortly after application. The still-living individuals that were located were re-treated in 2018, but more extensive revisits are needed in 2019 on Bar Island and elsewhere to check on the efficacy of past foliar applications.

Figure 6. Before and after Japanese Barberry treatments on Bar Island. (left photo 05/05/2016, right photo 05/11/2018; both NPS Photos)

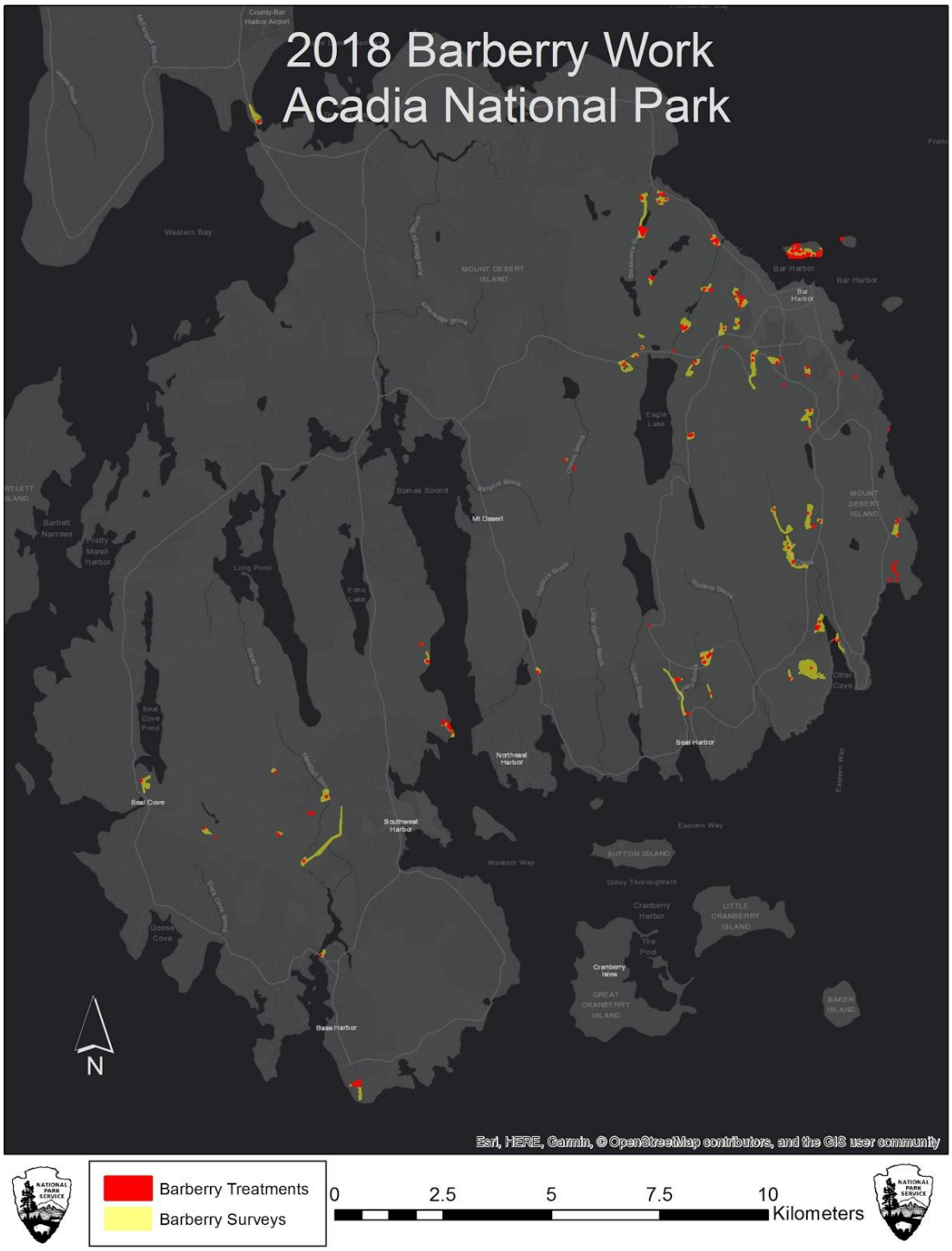

Figure 7. 2018 Japanese barberry treatments and surveys conducted in Acadia National Park.

Exotic Bush Honeysuckle

A concerted re-treatment effort was made in the Nursery / Sand Beach area in late May and early June, with a focus on exotic bush honeysuckle (*Lonicera* spp.) followed by Asiatic bittersweet (*Celastrus orbiculatus*) and Canada thistle (*Cirsium arvense*). Initial surveys and cut-stump treatments of honeysuckle at the Nursery occurred in spring 2014. Follow-up foliar treatments last occurred in 2015. These areas were all revisited in 2018, in addition to some previously unexplored areas around the Sand Beach parking lot (see **Figure 8** below) and between the Park Loop Road and the Beehive Lagoon, where further honeysuckle populations were found.

Figure 8. Jim and Nick perform cut-stump and foliar treatment of exotic bush honeysuckle on the western side of Sand Beach (05/30/2018, NPS Photo)

Other smaller satellite sites were also revisited to follow up on treatments from years past, including Enoch Mountain (west of the Park Loop Road and south of the Beehive Trail), Otter Cliffs Road (primarily the shoreline on the east side of the cove south of the causeway), and New Mills Meadow. Initial treatments were also carried out at new sites based on reports from park affiliates, including Motor Road Vista 57 on the Cadillac Summit Road, the beginning of the access road to the Bass Harbor Head Lighthouse (intersection of Lighthouse Road and Route 102A / Harbor Drive), and along the east side of the Schoodic Loop Road near Buck Cove.

Norway Maple

Monitoring

In August 2018 the EPMT visited the 10 Norway maple (*Acer platanoides*) forest monitoring plots at Compass Harbor, Ledgelawn and Duck Brook to track changes in forest characteristics after the first round of treatments in January 2018 (see **Figure 9** below). The most obvious change between 2017 and 2018 was the availability of sunlight to the forest floor, as large parts of the existing Norway maple canopy were removed during cut-stump treatment (see **Figure 10** below).

Figure 9. Diana Gurvich (Schoodic Institute Intern), Nick Stevenson and Alex Fetgatter collect Norway maple microplot data in Compass Harbor, 28 August 2018. NPS Photo

Figure 10. Canopy photos from before (left, 30 August 2017) and after (right, 28 August 2018) Norway maple treatment at Compass Harbor Plot 3, southeast quadrant at 7 meters from plot center. Note the drastic change in canopy gap after several large Norway maples were removed via cut-stump treatment. Further enlargement of the canopy gap is expected when the larger Norway maples treated with the hack-and-squirt method succumb to treatment. (NPS Photos)

Change in canopy cover is an important factor in predicting exotic plant invasion, in addition to the health of native understory species / groundcovers. Canopy cover is quantified using percent canopy openness, defined as the percentage of open sky seen from beneath a forest canopy; it is used to measure the amount of sunlight available to the forest understory. To measure percent canopy openness, canopy photos are taken at each of the eight microplots in each monitoring plot. To ensure the greatest possible accuracy, photos must be taken from the forest floor using a fisheye lens when skies are overcast; bright, sunny skies will skew the numbers higher. Canopy photos for all plots in Compass Harbor and Duck Brook were taken on August 28, 2018. Those

for Ledgelawn were taken August 29, 2018. Percent canopy openness is then calculated by uploading these canopy photos into the Gap Light Analyzer© (GLA) software (https://www.caryinstitute.org/science-program/our-scientists/dr-charles-d-canham/gap-light-analyzer-gla), within which the photos are analyzed and percent openness of the canopy calculated.

When compared to the 2017 numbers, the 2018 numbers for percent canopy openness confirm our hypothesis that, as Norway maples are removed from the canopy, greater gaps will be created resulting in more sunlight hitting the forest floor (see **Table 4** below). Averaged across all treatment plots in all sites, percent canopy openness increased by a factor of 49%. The most dramatic increase was measured at Duck Brook (89%), followed by Compass Harbor (48%), with Ledgelawn trailing at a modest 9% increase. Ledgelawn's marginal increase is largely explained by the overwhelming prevalence of very large, mature Norway maples at the treatment plots there, many of which failed to succumb to the hack-and-squirt method applied in January 2018, at least during the subsequent growing season. Compass Harbor also contained a fair number of large specimens that did not respond to treatment, while the treatments at Duck Brook were largely cut-stump so the effects on the canopy gap were more drastic and immediate. It is expected that percent canopy openness will continue to increase across all sites as these larger specimens finally succumb to treatment or are re-treated. Time will tell whether the treatments were completely ineffective, or if the treated specimens just had enough reserves in their cambium layers to send out one more year of foliage. The EPMT will monitor these individuals in Summer 2019 and re-treat as necessary.

	Average % Canopy Openness	
SITE Plot #	**2017**	**2018**
Compass Harbor (avg.)	**15.38**	**22.82**
1	16.79	17.93
2	16.46	26.2
3	12.89	24.34
Duck Brook (avg.)	**16.47**	**31.19**
1	16.41	35.75
2	16.52	26.64
Ledgelawn (avg.)	**15.4**	**16.75**
1	13.89	16.29
2	16.9	17.21
Overall Average	**15.75**	**23.48**

Table 4. 2017 – 2018 percent canopy openness averaged across microplots, all treatment plots in all sites.

It is worth noting that percent canopy openness in all control plots also increased slightly between 2017 and 2018, by an average factor of 9% (7% at Compass Harbor, 15% at Duck Brook, and 7% at Ledgelawn; see **Table 5** below). In theory percent canopy openness should not vary so much in these control plots between consecutive years, as no vegetation was removed from these areas. Rather than reflecting a significant reduction in canopy vegetation, this increase is largely explained by the weather conditions at the time the canopy photos were taken. In 2017 they were taken during overcast weather with little to no direct sunlight, which is the ideal condition for the Gap Light Analyzer® software to accurately assess percent canopy openness. In 2018 the photos were taken on a day with little cloud cover, resulting in direct sunlight filtering through the canopy in many photos. This direct sunlight can skew the data toward a higher percent canopy openness in several ways: the software may misinterpret bright surface reflections of direct sunlight (e.g., shiny bark or leaves) as open canopy; any glare present on the camera lens will cause the software to falsely interpret this as canopy openness; and if the sun itself is present in the photo it will obscure most canopy material between itself and the camera, thus creating an exaggerated calculation of canopy gap. Measures were taken to compensate for this when setting up the software for photo analysis by increasing the contrast threshold for photos that were clearly skewed by these factors. This is not a perfect fix, but it is the best solution known by the author as of this writing. The increase in percent canopy openness in the control plot at each site is less than that averaged across the treatment plots at each corresponding site, so it still stands to reason that the numbers do reflect an overall increase in canopy gap in the treatment plots, even accounting for the skewing factors. In future years it is recommended that canopy photos only be taken on overcast days to mitigate these complications.

	Average % Canopy Openness	
Site / Plot #	**2017**	**2018**
Compass Harbor / Plot 4	20.64	22.01
Duck Brook / Plot 3	19.42	22.26
Ledgelawn / Plot 3	22.64	24.15
Overall Average	**20.9**	**22.81**

Table 5. 2017 – 2018 percent canopy openness averaged across microplots, all control plots in all sites.

With the added sunlight coming through the canopy, the EPMT's primary concern is an increase in existing invasive plant populations, as well as the introduction of new ones. **Table 6** below shows that, when all treatment plots in all three sites are averaged by year, every invasive plant population (with the exception of Asiatic bittersweet) already present within the treatment plots showed an increase in average percent cover between 2017 and 2018. In addition, four species that were not present in the treatment plots in 2017 became established in 2018: oakforest woodrush (*Luzula luzuloides*), exotic bush honeysuckle species (*Lonicera* spp.), gypsyweed (*Veronica officinalis*), and narrowleaf bittercress (*Cardamine impatiens*). Overall invasive plant cover increased by almost a factor of five between 2017 and 2018.

The control plots, on the other hand, tell a different story. The control plots at both Duck Brook and Ledgelawn had no invasive cover in both 2017 and 2018. The control plot at Compass Harbor did contain some invasive cover, but this was relatively small compared to its treatment plots. Only one invasive plant population was found there in 2017 (non-native woodrush, *Luzula* spp.), and this had decreased significantly in 2018 alongside a small addition of invasive *Euonymus* spp.

A closer look at Table 6 reveals that most invasive plant cover occurs in the Compass Harbor treatment plots. Those at Duck Brook and Ledgelawn are, by comparison, relatively clean. A few different factors may account for this. Much of Compass Harbor's historic use was as a commercial nursery, which accounts for the great diversity of non-native plants in that area. While both Duck Brook and Ledgelawn also have histories of heavy human disturbance (mostly old home sites around Duck Brook and an old dump / maintenance lot around Ledgelawn), they likely did not have the same volume of plant material moving in and out as did Compass Harbor. In addition, much of the forest canopy at Duck Brook consists of native trees, which provide an ample seed bank each year to compete with any encroaching invasives. The soils at Ledgelawn may also play a role in suppressing new growth, either native or non-native. This site's history as an old dump site likely translates to poor soil quality. The increase in canopy gap after the first year of Norway maple treatment is also more extreme at Compass Harbor than at the other two sites, largely because most of the canopy at Duck Brook consists of native trees and the canopy at Ledgelawn consists of very mature Norway maple that have not, at the time of this writing, succumbed to hack-and-squirt treatment.

Table 6. Average percent cover class* of invasive plant species in Norway maple forest monitoring plots, 2017 and 2018.

	All Sites				**Compass Harbor**			
	Treatment Plots		Control Plots		Treatment Plots		Control Plot	
Species	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
DACGLO	0.29	1.14	0	0	0.67	0.76	0	0
CELORB	0.28	0	0	0	0.33	0	0	0
CONMAJ	0.24	0.86	0	0	0.56	0.57	0	0
LIGSPP	0.21	0.86	0	0	0.5	0.86	0	0
EUOSPP	0.14	0.43	0	0.33	0.33	0.29	0	1
ALLPET	0.14	0.29	0	0	0	0	0	0
LUZLUZ	0	1.2	1.22	0.93	0	2.57	3.67	2.8
LONSPP	0	0.71	0	0	0	0.29	0	0
VEROFF	0	0.29	0	0	0	0	0	0
CARIMP	0	0.29	0	0	0	0	0	0
LUZSPP	0	0	1	0	0	0	3	0
Average	**0.12**	**0.55**	**0.2**	**0.11**	**0.22**	**0.49**	**0.61**	**0.35**

	Duck Brook				Ledgelawn			
	Treatment Plots		Control Plot		Treatment Plots		Control Plot	
Species	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
DACGLO	0	0	0	0	0	0	0	0
CELORB	0	0	0	0	0.5	0	0	0
CONMAJ	0	0	0	0	0	0	0	0
LIGSPP	0	0	0	0	0	0	0	0
EUOSPP	0	0	0	0	0	0	0	0
ALLPET	0	0	0	0	0.5	0.5	0	0
LUZLUZ	0	0	0	0	0	0	0	0
LONSPP	0	0.5	0	0	0	0	0	0
VEROFF	0	1	0	0	0	0	0	0
CARIMP	0	0	0	0	0	0.5	0	0
LUZSPP	0	0	0	0	0	0	0	0
Average	**0**	**0.14**	**0**	**0**	**0.09**	**0.09**	**0**	**0**

**percent cover classes are defined as follows: (0) = 0% cover; (1) = <1% cover; (2) = 1-5%; (3) = 6-25%; (4) = 26-50%; (5) = 50-75%; and (6) = 75-100%*

There is room for hope, however. **Table 7** below shows that, when all treatment plots in all three sites are averaged by year, all existing populations of native non-tree woody plant species (with the exception of lowbush blueberry, *Vaccinium angustifolium*), are also on the increase after initial Norway maple treatment. In addition, four new species made an appearance, including alternate-leaved dogwood (*Swida alternifolia*), maple-leaved viburnum (*Viburnum acerifolium*), and an unspecified member of the grape family (most likely Virginia creeper, *Parthenocissus quinquefolia*). We hope that these populations (among others) will act as native source populations to repopulate areas in the vicinity left bare after future invasive plant treatments. Overall percent cover of native non-tree woody species increased by roughly a factor of four between 2017 and 2018.

Broken down by site, the treatment plots tell a slightly more nuanced story. Duck Brook had the widest variety and densest cover of native non-tree woody vegetation in 2017, while Ledgelawn only had one species (Virginia creeper, *Parthenocissus quinquefolia*) and Compass Harbor had none. This is as suspected based on the site characteristics outlined above in the narrative for Table 6. Ledgelawn's potentially poor soils and heavily-shaded Norway maple canopy, and Compass Harbor's preponderance of non-native competition, may help explain the scarcity of native woody vegetation at these sites in 2017. 2018 showed an increase across all sites, by virtue of expansion of existing populations as well as the addition of new species.

Table 7. Average percent cover classes of native non-tree woody plant species in Norway maple forest monitoring plots, 2017 and 2018.

	All Sites				Compass Harbor			
	Treatment Plots		Control Plots		Treatment Plots		Control Plot	
Species	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
PARQUI	0.5	0.67	0	0	0	0	0	0
ROSSPP	0.17	0.29	0	0	0	0	0	0
SPISPP	0.17	0.29	0.33	0.33	0	0	0	0
VACANG	0.17	0	0.67	0.67	0	0	0	0
UNKSPP	0	1.14	0	0	0	2	0	0
VIBACE	0	0.57	0	0	0	0	0	0
VITSPP	0	0.43	0	0	0	1	0	0
SWIALT	0	0.29	0	0	0	0	0	0
COMPER	0	0	0.5	0.67	0	0	0	0
VIBTRI	0	0	0	0	0	0	0	0
RUBSPP	0	0	0.33	0	0	0	0	0
CRASPP	0	0	0	0.33	0	0	0	0
Average	**0.08**	**0.31**	**0.15**	**0.17**	**0**	**0.25**	**0**	**0**

	Duck Brook				Ledgelawn			
	Treatment Plots		Control Plot		Treatment Plots		Control Plot	
Species	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
PARQUI	1	1.33	0	0	0.5	1	0	0
ROSSPP	0.5	1	0	0	0	0	0	0
SPISPP	0.5	1	1	1	0	0	0	0
VACANG	0.5	0	0	0	0	0	2	2
UNKSPP	0	1	0	0	0	0	0	0
VIBACE	0	0	0	0	0	2	0	0
VITSPP	0	0	0	0	0	0	0	0
SWIALT	0	0	0	0	0	1	0	0
COMPER	0	0	0	0	0	0	1.5	2
VIBTRI	0	0	0	0	0	1.33	0	0
RUBSPP	0	0	0	0	0	0	1	0
CRASPP	0	0	0	0	0	0	0	1
Average	**0.21**	**0.36**	**0.08**	**0.08**	**0.04**	**0.44**	**0.38**	**0.42**

Treatment

Active treatment of Norway maple for Fall 2018 began in late October in park lands surrounding the Otter Cove Boat Launch (off of Grover Avenue in Otter Creek). Prior to this point EPMT staff had been flagging candidates for removal prior to leaf senescence to minimize uncertainties

over identification. With the exception of two large trees near the old foundation at the top of the hill just north of the public boat launch, the rest of the Norway maples here were small enough to cut by handsaw.

Other medium-sized sites visited in fall 2018 for Norway maple treatment include:

- Flye Farm, with the population concentrated around Flye Cemetery (there are three very large Norway maples planted within the cemetery itself — these were not removed, so follow-up visits will be required indefinitely to keep an eye out for seedlings);
- Duck Brook, with the population mostly concentrated between Paradise Hill Road and Route 3 on both sides of Duck Brook itself (there are still quite a few left standing in the woods on the southeast side of Duck Brook close to Route 3, a number of which are close to power lines);
- Harden Farm, where the majority of trees were found in the woods near Kebo Street, between Harden Farm Road and Holy Redeemer Cemetery (a number of individuals were left standing in the woods to the north of the cemetery due to their proximity to power lines);
- Nursery (see **Figures 11** and **12** below), with treatments focused on the forest margin surrounding the Sand Beach House and its driveway (a number of medium-sized individuals were left standing along the west side of the Great Head Trail as you head south toward Sand Beach);
- Cleftstone (most trees were found and treated close to Cleftstone Road, surrounding the old driveway / social trail up to the old house foundation); and
- Jordan Pond Carriage Road near the Jordan Pond Road Bridge (some individuals still need to be cut upon consulting with adjacent landowners, due to their proximity to the property line).

Figure 11. Nick Stevenson prepares for clean-up after the felling of a large Norway maple at the Nursery, 29 November 2018. NPS Photo

Figure 12. Before (left) and after (right) Norway maple removal at the Nursery, 29 November 2018. NPS Photos

We addressed some smaller sites (i.e., sites with just one to a few Norway maples to treat), including the intersection of Great Meadow Drive and the Park Loop Road, Thailand, the Seal Harbor Beach Parking Lot (one large individual was cut-stumped, but a larger one was left standing due to its proximity to the parking lot and questions over whether or not it is growing on park land), the Jordan Pond Erosion Site, Jordan Pond House (two mature trees on the south end of the loop parking lot near the house itself, and a few smaller ones in the forest margin to the west of the blueberry field overlooking Jordan Pond), the Hulls Cove Visitor Center parking lot (one individual near the southwest corner), and Thompson Island (one individual on the east side of the causeway just south of the bridge).

As a general rule, any Norway maple close enough to fall on a trail, road or carriage road was felled and then stump-treated with herbicide (either 33% Rodeo or 25% Garlon 4 Ultra) to prevent creation of a future hazard tree. We felled many trees in the forest interior as well, as long as it was safe to do so. Trees felled within eyeshot of the public were cut up and dispersed to minimize visual impacts and to increase the rate of decay. We left trees felled in the forest interior outside public view intact to decay as naturally as possible. Particularly large trees (>12 inches DBH or so) in the forest interior (posing no risk of falling on passersby) were left standing and the hack-and-squirt method was used for treatment (see **Figure 13** below). For this method an axe or hatchet is used to make cuts into the cambium layer of the tree around its entire circumference, followed by herbicide application into the wounds (either 33% Rodeo or 25% Garlon 4 Ultra). Once translocated into the roots the chemical will kill the tree and leave a dead snag behind, which can provide valuable habitat for wildlife.

The goal of Norway maple treatments for fall 2018 was to finish most of the "satellite" sites (i.e., any populations that don't fall within the Compass Harbor, Duck Brook, or Ledgelawn areas), so these three larger sites can be the focus for upcoming years (see **Figure 14** below). Treatments were conducted in these three areas in and around the treatment plots in January 2018, but these sites haven't seen any active treatment since then. As noted above, most (if not all) of the specimens treated with the hack-and-squirt method in these areas did not appear to die, as they achieved full leaf-out in summer 2018. The EPMT will continue monitoring these individuals in 2019, and will retreat if leaf-out occurs again. Since treatment began in January 2018, an estimated 228 Norway maples have been cut-stumped and 26 have been treated using hack-and-squirt.

Figure 13. Alex Fetgatter does hack-and-squirt treatment on a large Norway maple at Duck Brook, 8 November 2018. NPS Photo.

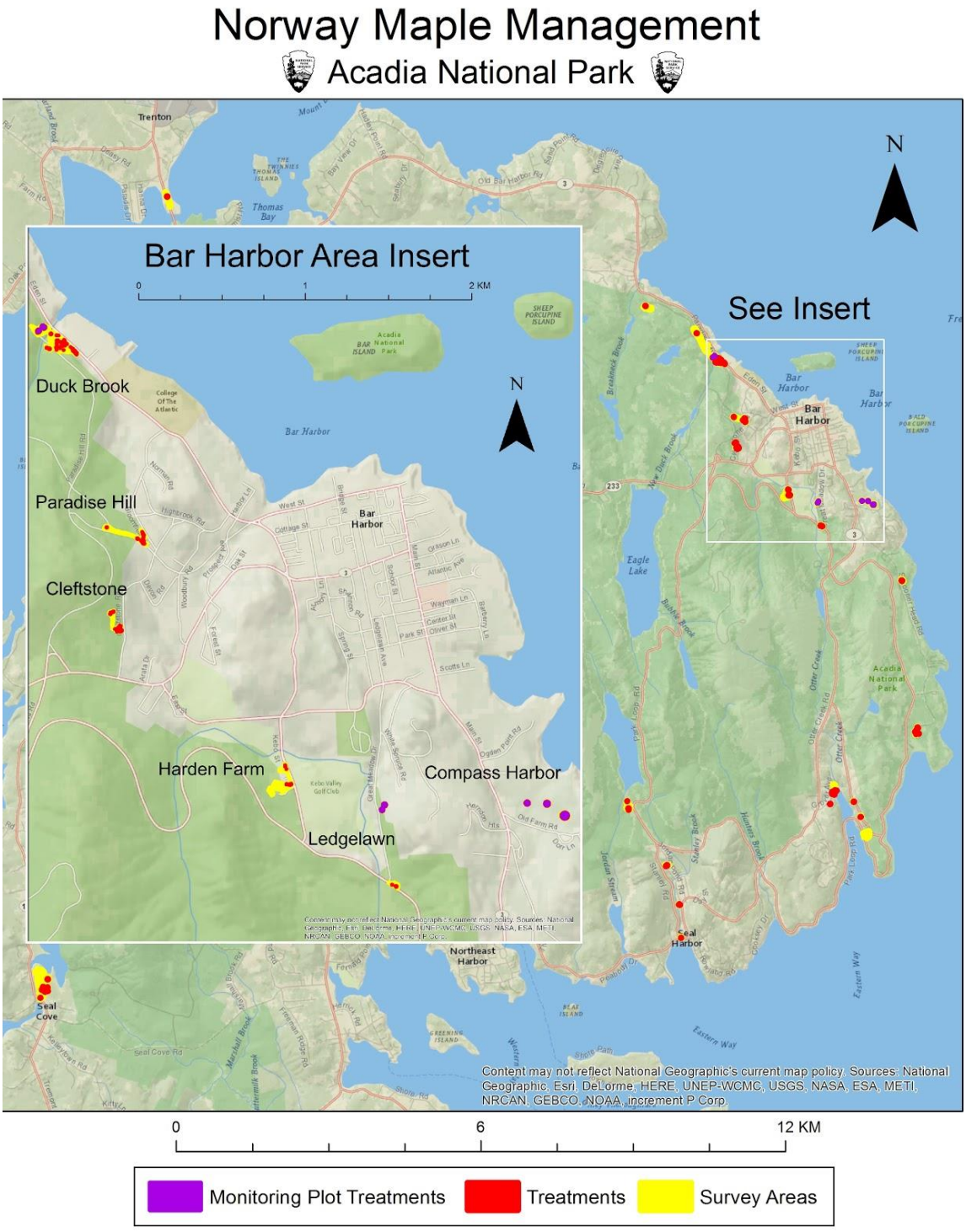

Figure 14: Norway maple management at Acadia National Park in 2018.

Glossy Buckthorn

2018 field work included surveying and treating glossy buckthorn (*Rhamnus frangula* syn. *Frangula alnus*) populations at a number of new sites. In addition to continuing treatment efforts at major known population sites (mainly Great Meadow and Canon Brook this year), increased reports from Park affiliates and increased EPMT scouting efforts enlarged the geographic extent of buckthorn management, a trend which has continued over the last few years (see **Figure 16** below). While total surveyed acres for buckthorn has fluctuated since 2016 (321.38 acres in 2016, 263.23 acres in 2017, and 320.64 acres in 2018), the total number of sites treated for buckthorn has steadily increased (19 sites in 2016, 26 sites in 2017, and 45 sites in 2018).

Surveys turned up new glossy buckthorn populations in 2018 in the following areas, among others: Bubble Brook (see **Figure 15** below), Cadillac Summit Road, Motor Road Vista 57, Seal Cove Road, Marshall Brook Fire Road, and Tremont School. The park property near Tremont School needs further scouting in 2019, as mature individuals have been found sporadically along the school's nature trail as well as a dense mature patch on private property on the east side of Marsh Road. If this population undergoes treatment in 2019, it could take a fair amount of staff time and effort. Further scouting is also needed around the wetland complex at the end of Marshall Brook Fire Road, as some mature specimens were found in and around the forest margin in this area. As this is located upstream of the Tremont School, it is possible that these populations are connected. With the finding of some mid-size buckthorn populations along the Seal Cove Road corridor this year, an additional goal for 2019 may be to scout further afield in the Heath Brook wetland complex north of the road.

Figure 15. A new glossy buckthorn site at the Bubble Brook wetland, 15 October 2018. NPS Photo.

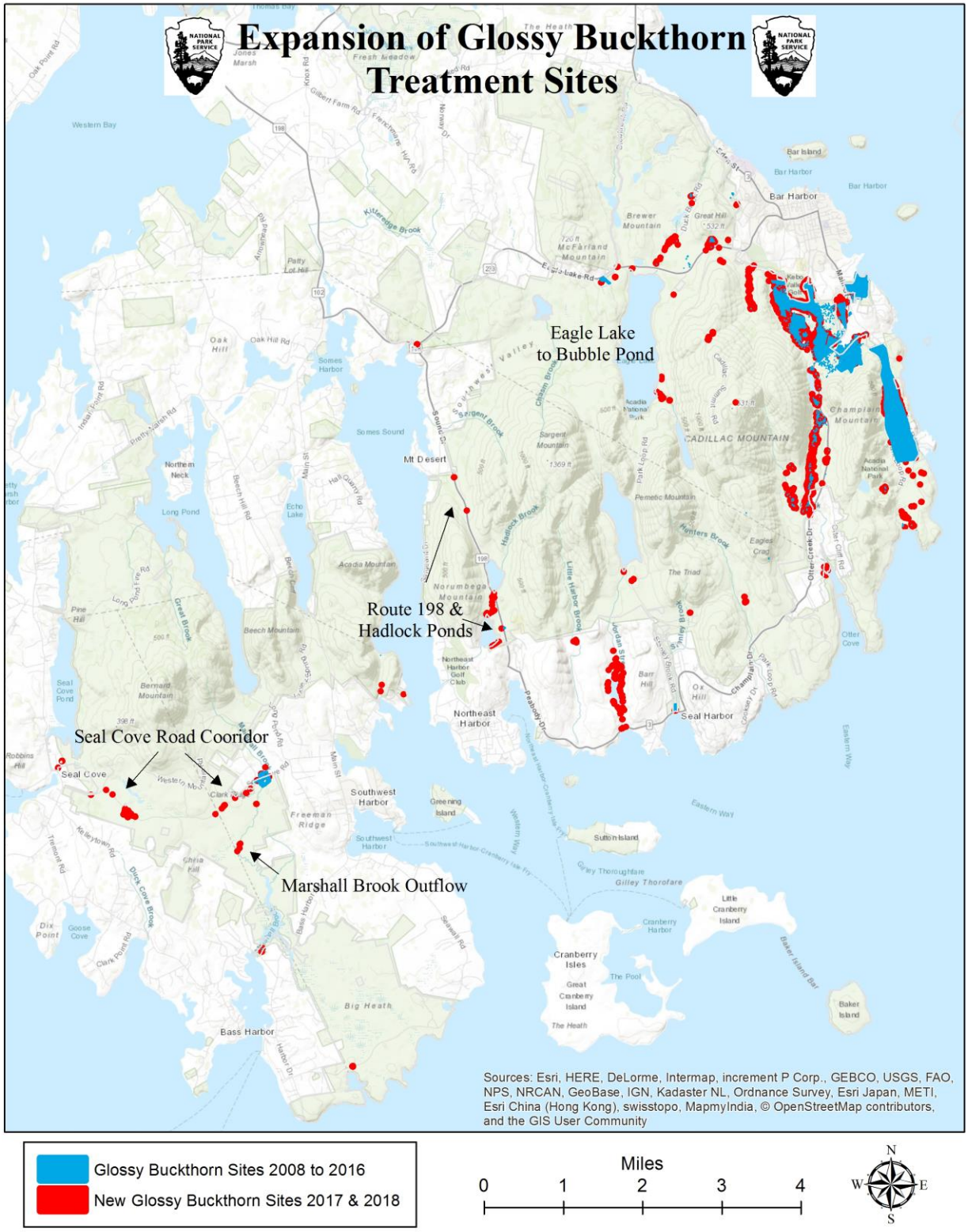

Figure 16: Expansion of glossy buckthorn (*Rhamnus frangula*) sites in 2017 and 2018.

Management Activities by Location

Outer Islands (all islands accessed by boat or gravel bar at low tide)

In an effort to manage IEPs on Park islands, the EPMT tries to visit several islands only accessible by boat every year. Canada thistle (*Cirsium arvense*) and bull thistle (*Cirsium vulgare*), both commonly found on coastal islands in Maine, have dispersed along many island shorelines in Acadia. In 2018 exotic bush honeysuckle, Asiatic bittersweet, common privet, Japanese barberry, and thistle species were found and targeted on Isle au Haut, the Hop, Sheep Porcupine Island, Baker Island, Bar Island, and Schoodic Island.

Isle au Haut

The EPMT made a trip to Isle au Haut from July 24 - 26, 2018 to treat historic Canada and bull thistle populations along the southern coastline. As the vast majority of park-owned coastline had been surveyed in 2016, surveys were targeted in areas where populations had already been documented, thus saving time and allowing for scouting in new areas.

One of the new areas explored began as a monitoring check on a small Japanese barberry population that was treated in 2016. Further scouting around this area revealed many more specimens to the south of the original finding, dotting the bank of the water channels flowing through the wetlands there. The EPMT surveyed and treated as many individuals as time allowed before they had to catch the ferry back to Stonington. The map insert in **Figure 21** below gives a detailed view of this new population. Plans for the 2019 field season should include a visit to Isle au Haut in May to continue surveys and treatments in this area. Barberry is easiest to spot during this timeframe because it is one of the few woody plants leafing out at that point.

Similar to Baker in 2016, the EPMT was unable to visit Isle au Haut in 2017. When one looks at the numbers it becomes clear that annual visits are necessary to keep the Canada thistle populations in check, at least until they are reduced to maintenance thresholds. In 2015, 0.076 infested acres of Canada thistle were found and treated; in 2016, this number decreased to 0.012 infested acres. However in 2018, after no treatment in 2017, this number jumped back up to 0.019 infested acres. Canada thistle populations had been on the decline prior to the skipped treatments in 2017, after which point they rebounded slightly. See **Figure 17** below for a photo point of Canada thistle treatment on the northwest corner of Isle au Haut's Western Ear.

Figure 17. Before (left, 27 July 2016) and after (right, 24 July 2018) Canada thistle treatment on the northwest corner of Isle au Haut's Western Ear. NPS Photos.

Bull thistle populations, on the other hand, have shown a steady decrease in spite of the skipped treatments in 2017. Treated infested acres for bull thistle decreased from 0.012 acres in 2015, to 0.10 acres in 2016, to 0.007 acres in 2018. This is likely because bull thistle is a biennial, so as long as treatments for one year include both first-year rosettes and second-year bolted seed-producers, treatments can be skipped for the following year without adding to the seed bank (assuming that your treatment is fully successful and all germinants the following year remain in the first-year, non-fruiting rosette stage). Canada thistle, on the other hand, is a perennial and each individual has the capacity to put out seed every year.

Japanese barberry was first treated on Isle au Haut in 2016, when the EPMT followed up on a finding by NETN Wetland Monitoring Biologists. Skipped years are usually not a problem for barberry treatment, assuming initial treatments were successful, as this species in particular tends to respond very well to herbicide application (i.e., the entire plant usually dies after the first treatment). The increase in treated infested acres from 2016 to 2018 (0.002 infested acres versus 0.010 infested acres, respectively) is a result of the large new population found in 2018 (see **Figure18** below), as opposed to a drastic population explosion between those two years. Based on the maturity of most barberry individuals there, this "new" large population had likely been established years prior to 2018, but had just not yet been discovered.

Figure 18. Part of a newly discovered population of Japanese barberry in a remote Isle au Haut wetland, 26 July 2018. NPS Photo

During this trip the EPMT worked closely with Isle au Haut Rangers Alison Richardson and Kristin Dillon to train them on identification and treatment of the common invasive plants found out there (see **Figure 19** below). The hope is that they can use this information in their day-to-day activities throughout the summer and report any new findings, since they see much more of the island than the EPMT can cover in such a short trip. Perhaps in the future, if existing populations are reduced to a maintenance level, Isle au Haut rangers can afford to spend a little time doing treatments as well. This would save time and money by preventing the need for the EPMT to make annual visits.

Figure 19. With guidance from EPMT staff, Isle au Haut Rangers Alison Richardson and Kristin Dillon treat Canada thistle near Duck Harbor Campground, 25 July 2018. NPS Photo

EPMT Program Coordinator Jesse Wheeler also gave a presentation to the Isle au Haut community entitled “Invasive Exotic Plants in Our Backyard: What We’ve Learned in Acadia National Park.” This event was held in the Town Hall auditorium and open to the public. Nine members of the Isle au Haut community were in attendance. The presentation gave an introduction to the basic ecology of invasive plants and their impact on the local environment, as well as an overview of what Acadia staff are doing to protect park lands from invasion. Jesse also touched on identification of the exotics commonly found on Isle au Haut (e.g., Canada and bull thistles, Japanese barberry), in addition to treatment methods that have been most effective over the years. The hope is that landowners around the island will use this information to assess their own properties for the presence of these plants, and attempt to manage them if possible. It is also hoped they will be encouraged to use native plants for any future landscaping. Increased public knowledge will lead to more eyes on the ground and potentially more reports of invasive plant populations in and near park lands.

Figure 20. Jesse Wheeler gives an invasive plant presentation to Isle au Haut residents at the Isle au Haut Town Hall, 25 July 2018. NPS Photo

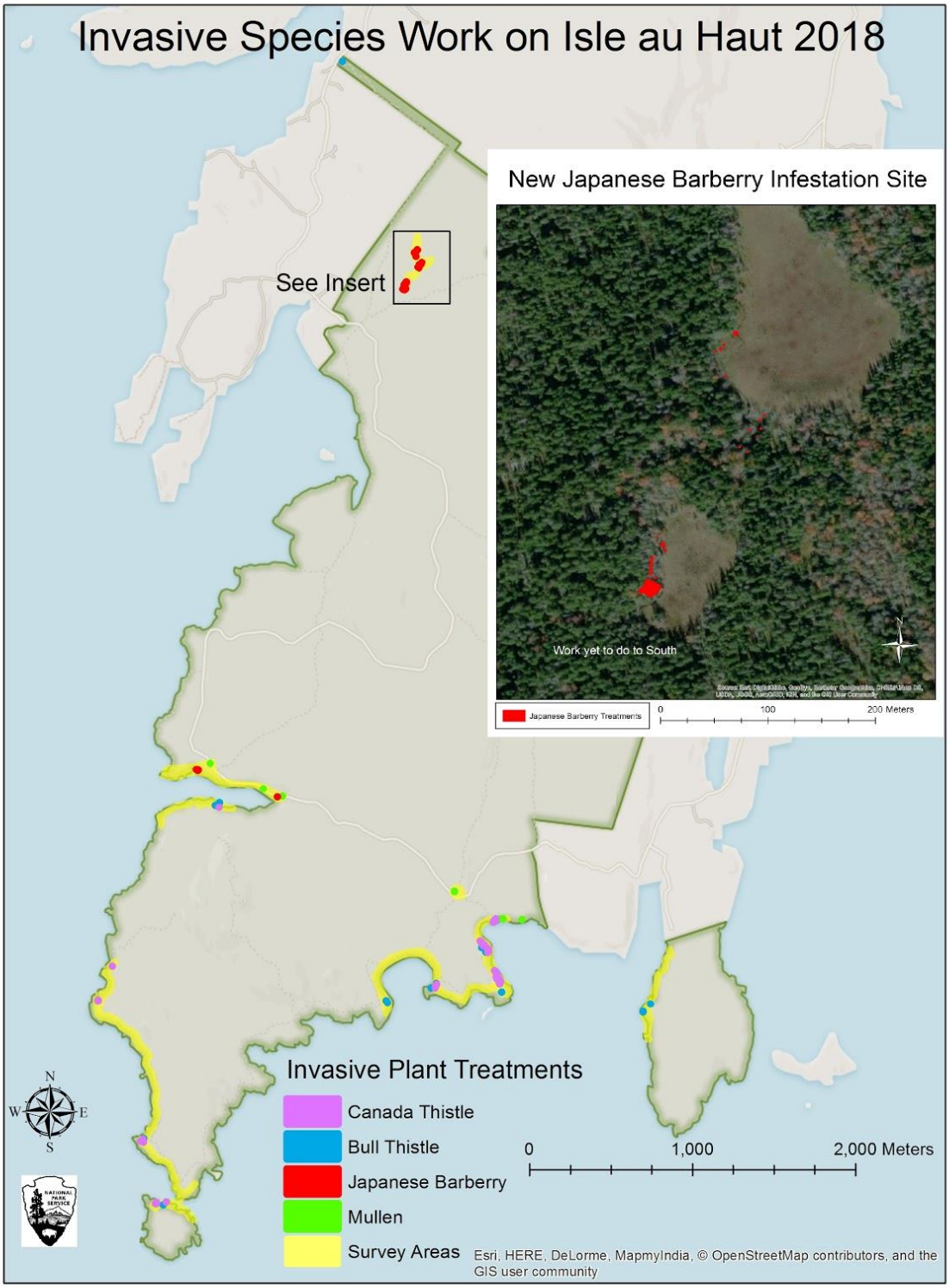

Figure 21. Map of invasive plant work conducted on Isle au Haut in 2018, including the newly discovered Japanese barberry population.

The Hop Island

The EPMT made two trips to The Hop in 2018 to complete a second round of foliar herbicide applications on the large exotic bush honeysuckle (*Lonicera* spp.) population there. Initial attack cut-stump herbicide treatments were completed in 2017, and an initial round of follow-up foliar treatments was completed on a large portion of the low-growing individuals in that year as well. We have made progress in reducing the mature reproductive population on the Hop. 0.166 infested acres were cut-stumped in 2017, while only 0.008 infested acres required cut-stumping in 2018, suggesting that very few fruiting individuals are left. It may take some years for the foliar infested acres numbers to decrease dramatically as the seed bank is exhausted over time. We spent fewer hours working on The Hop in 2018 (27) compared to 2017 (107) as we round the time and energy corner towards maintenance level effort. Annual or biannual visits must be emphasized to continue suppression of stump sprouts and the emerging seed bank, making sure not to repeat the mistake of ignoring the island for many years, only to find invasive shrubs have taken hold again. **Figure 22** below shows photo points of *Lonicera* spp. cut-stump treatment at two locations on the Hop.

Figure 22. Before (left) and after (right) images of exotic bush honeysuckle (*Lonicera* spp.) cut-stump management on The Hop. The upper left photo (22 September 2015) and upper right photo (25 June 2018) compare honeysuckle outcrops with Long Porcupine Island in the background. The lower left photo (5 July 2017) and lower right photo (25 June 2018) show management of a large honeysuckle stand looking east over Frenchman Bay. All NPS photos

Sheep Porcupine Island

The EPMT treated invasive plants on Sheep Porcupine Island for the first time in the program's history. Following a survey and confirmation of invasive plants in 2015, we had an opportunity to visit the island for treatments in September 2018 (see the map in **Figure 24** below). The EPMT joined a group from Schoodic Institute to sample forest plots and treat several species of invasive plants, including exotic bush honeysuckle, Japanese barberry, Asiatic bittersweet, and privet. Weather and boat troubles dictated only one day of treatment, in which the team was able to treat about half the population of exotic bush honeysuckle, the most prominent invasive plant on the island. The island is closed for access April 1 - August 31 for bald eagle nesting, so the window for treatment is limited with September at the mature fruiting stage for honeysuckle and foliage already starting to senesce (see **Figure 23** below). This means we will need to revisit the island in September 2019 and then follow up after that to ensure we have removed most of the reproductive plants.

Figure 23. A large exotic bush honeysuckle grows on the western shore of Acadia's Sheep Porcupine Island in Frenchman Bay. Some of the leaves are turning yellow in this September 4, 2018 photo. This is a site that encounters harsh environmental conditions which trigger early senescence. This particular honeysuckle escaped treatment in 2018 and should be managed in 2019. NPS Photo

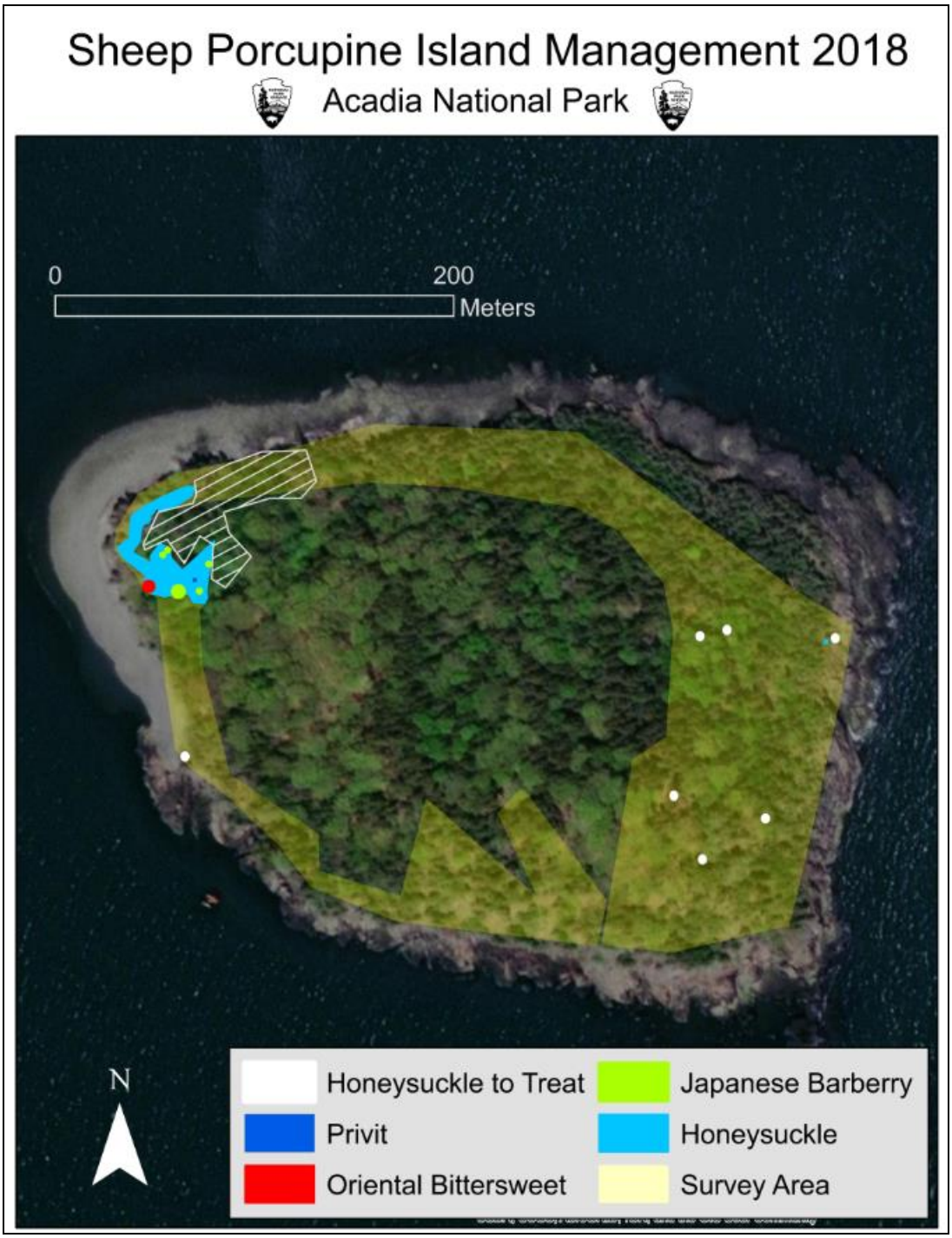

Figure 24. Treatment and survey map for Sheep Porcupine Island, 4 September 2018.

Baker Island

Baker Island was surveyed and treated for Canada and bull thistles (*Cirsium arvense* and *C. vulgare*, respectively) on August 21, 2018 (see **Figure 25** below). Similar to 2017, this treatment occurred later than hoped and most of the thistles had gone to seed by this point. Also similar to 2017, the team did not have sufficient time to cover the entire island as in years past. In 2015, the last year Baker was covered in its entirety (at least the open areas where thistles are most likely to grow), 32.9 acres were surveyed, of which 0.016 acres were infested with Canada thistle and 0.015 acres were infested with bull thistle.

The EPMT did not visit Baker at all in 2016. In 2017, 12.14 acres were surveyed, of which 0.045 were infested with Canada thistle and 0.0052 were infested with bull thistle. In 2018, 13.01 acres were surveyed, of which 0.091 acres were infested with Canada thistle and 0.024 acres were infested with bull thistle. These numbers indicate the importance of thorough annual treatment visits to keep thistle populations below management thresholds. Infested acres of Canada thistle increased six-fold between 2015 and 2018, even though the 2018 surveyed area was a little over one-third that of 2015.

Figure 25. Nick Stevenson conducts foliar herbicide treatments on Canada thistle on Baker Island, 21 August 2018. NPS Photo

Bar Island

In 2018 the EPMT continued managing invasive privet (*Ligustrum vulgare*), barberry (*Berberis* spp.), Asiatic bittersweet (*Celastrus orbiculatus*), exotic bush honeysuckle (*Lonicera morrowii*), and more on Bar Island. More than 55 staff hours were spent surveying and treating approximately one third of the island. The island's southern half is heavily invaded and has been managed for several years now (see **Figure 26** below); thus most treatments this year involved foliar treatment of small plants. This area will still have seedlings in 2019, but these should be immature, and follow-up treatments can likely wait until 2020. The exception to this is the island's southern slope, which is too steep to navigate with backpack sprayers. This should be treated with smaller equipment from both the top and the base of the cliff in 2019.

Parts of the northwestern quadrant of the island were also surveyed in 2018, and numerous mature barberry shrubs were found there. In 2019 further surveys should be conducted in the remaining northern and eastern areas, especially where previous barberry were managed last in 2016. In 2018 barberry were also found further east on the island than had previously been seen, and other populations could remain undiscovered. As mentioned above under the section devoted to Japanese barberry treatment, some individuals treated with foliar herbicide in 2016 were found to still be at least partially alive. Those found were re-treated, but further scouting is required to determine the extent of this failed initial treatment. Routine follow-up monitoring visits will be implemented in the future to verify treatment efficacy.

Figure 26. Bar Island privet treatments before (left, 12 May 2016) and after (right, 21 May 2018). NPS Photos

Schoodic Island

Schoodic Island was visited by the EPMT for the first time on September 5, 2018 as part of a joint work effort with staff from the Schoodic Institute. This island is located off the southeastern tip of the Schoodic Peninsula, and only the southern third is forested. Time was limited on this trip, so only the southern half of the island was surveyed for invasive plants, including much of the forested areas and the coastal band around it. No woody invasive species

were found; however there were scattered patches of Canada thistle (*Cirsium arvense*; see **Figure 27** below) and bull thistle (*Cirsium vulgare*). It is worth noting that the open island is also heavily invaded by non-managed exotic plants such as curly dock (*Rumex crispus*) and wild radish *(Raphanus raphanistrum*).

The thistles found were partially treated, but the largest Canada thistle population on the eastern side of the island was missed (see the map in **Figure 29** under the Schoodic Peninsula section below). It is likely that the non-forested northern portion of Schoodic Island contains further patches of invasive thistle, possibly even larger ones, but future treatments of the island may be infeasible due to the size of the infestation. It is likely that two or three days with backpack sprayers would be needed to completely treat the island. There are also problems with getting to the island. For this trip, the Schoodic Institute chartered a private ferry to the island to access research plots, and the EPMT was able to join them, but this will not be possible every year. Due to their proximity to Schoodic Island, thistle surveys of the nearby Schoodic Peninsula shores and Little Moose Island should be conducted in the future.

Figure 27. A large population of Canada thistle discovered in 2018 on the eastern side of Schoodic Island, 5 September 2018. NPS Photo

Schoodic Peninsula

The EPMT spent two days surveying and managing invasive plants on the Schoodic Peninsula in 2018, after not working there in 2017 (see map in **Figure 29** below). As in past years, the site requiring the most resources was Frazer Point, which is invaded by numerous woody species and Canada thistle (*Cirsium arvense*). Fairly extensive surveys were conducted in several other areas as well. Crews searched the bike trail system by bicycle, and a couple of honeysuckle (*Lonicera morrowii*) and scattered coltsfoot (*Tussilago farfara*) were found and treated.

The Schoodic Woods Campground was also surveyed, as well as parts of the Schoodic Institute campus, where thistles and a few other herbaceous invasive plants were found and treated.

Finally, several reported honeysuckle were treated off the Schoodic Loop Road (see **Figure 28** below) and near the ranger cabin. The peninsula should be visited at least once each season to treat Canada thistle populations and Frazer Point, and recommendations for new surveys on the Schoodic Peninsula include the Alder Trail, Little Moose Island, and more of the Institute campus.

Figure 28. The EPMT removes a large exotic bush honeysuckle on the Schoodic Loop Road near Buck Cove, 20 June 2018. NPS Photo

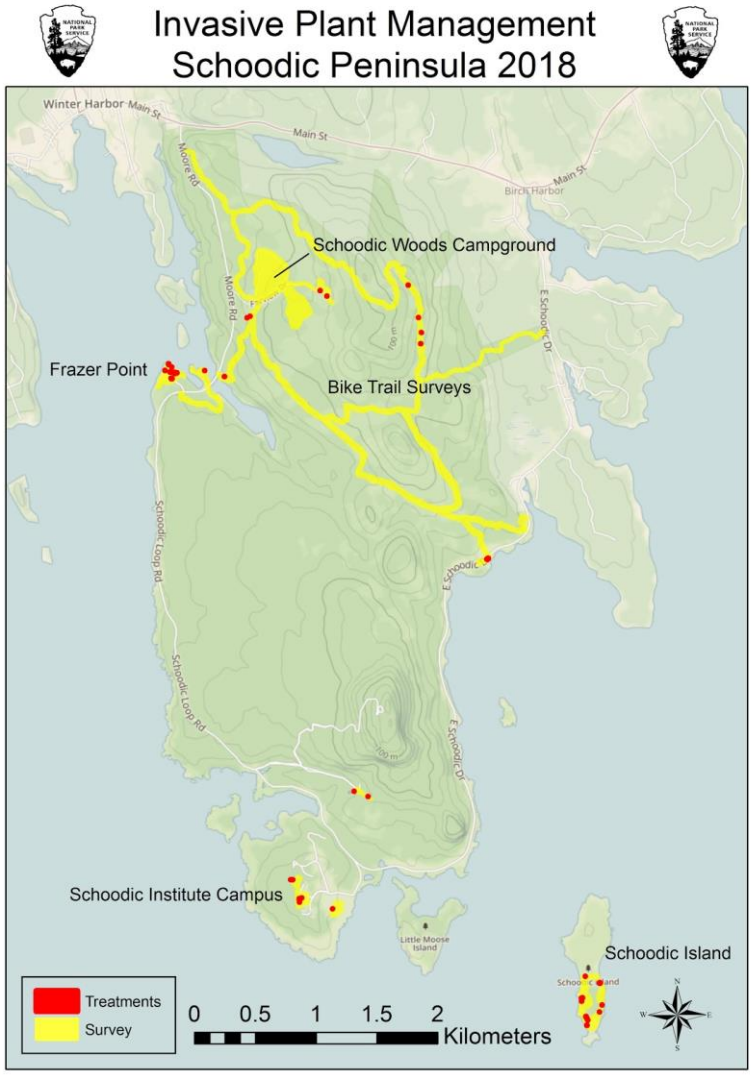

Figure 29. Map of exotic plant treatments and surveys on Schoodic Peninsula and Schoodic Island in 2018.

Canon Brook / Otter Creek Watershed

In 2018 the EPMT performed the second round of glossy buckthorn treatments in the Canon Brook watershed, as a follow-up to the initial attack cut-stump treatments in 2017 (see the map in **Figure 30** below for survey and treatment areas). These were primarily foliar applications mixed with as-needed cut-stump treatments for either larger individuals that were missed or skipped in 2017 (some stems were skipped in 2017 because they were considered small enough to leave for the following year's foliar treatment, but by 2018 they had grown too large and had to be cut). The entire Canon Brook corridor was treated in 2018, from The Tarn south to the Route 3 outlet, as well as the stream branches and beaver impoundments west of the main drainage.

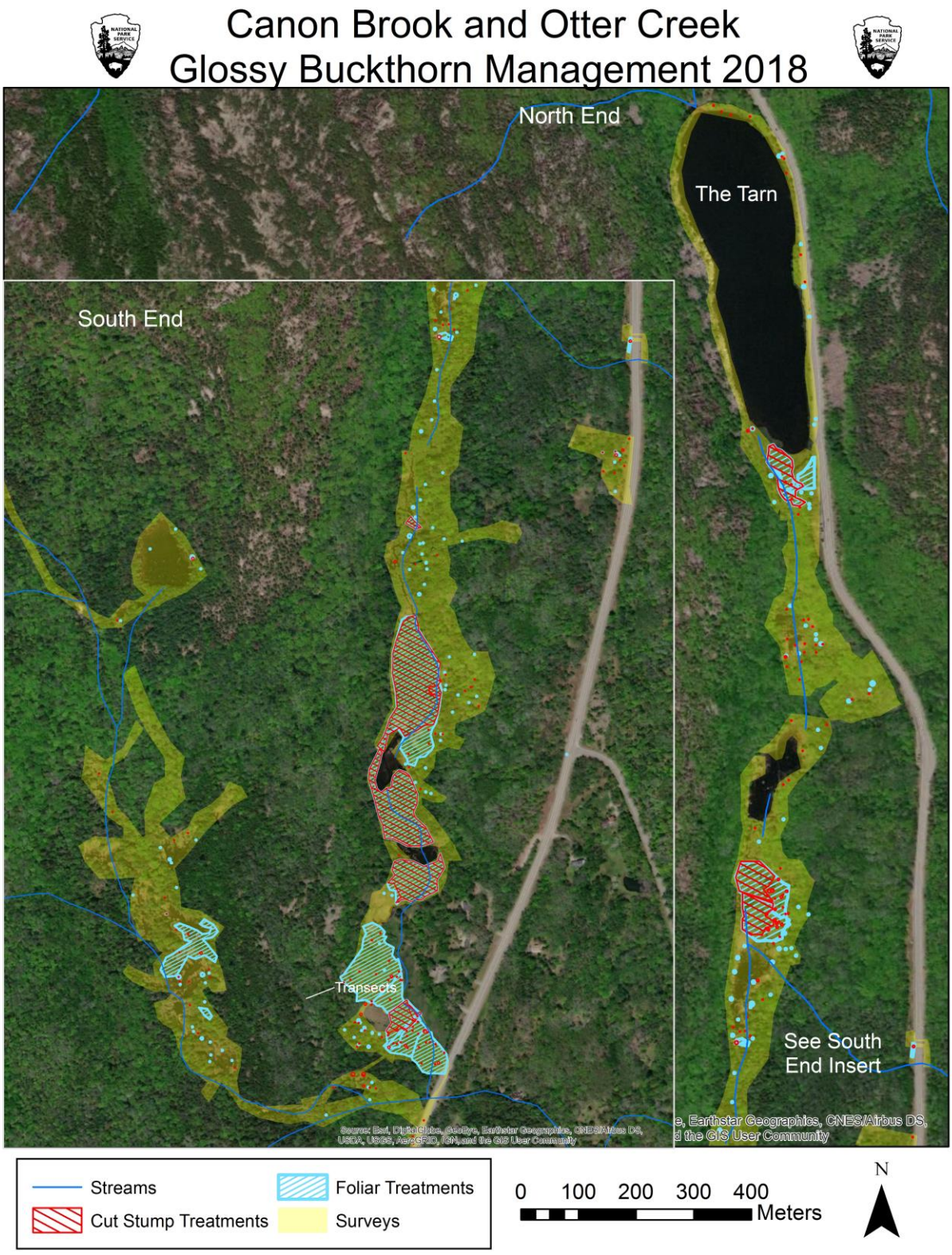

Figure 30. Glossy buckthorn management at Canon Brook / Otter Creek in 2018.

The four glossy buckthorn monitoring transects established in 2017 were revisited prior to beginning treatments for 2018, so the effects of the 2017 treatment could be accurately captured. **Tables 8** and **9** below display the findings for both 2017 and 2018. The number of reproductive (i.e., fruiting) stems decreased by an average of 66% between the two years. This is as expected, since most mature reproductive individuals were removed during initial attack.

The number of vegetative (i.e., non-fruiting) stems increased by an average of 61%. This is not surprising given the vast seed bank resulting from years of dense cover by mature reproductive individuals. Some of these vegetative stems were re-sprouts from stumps treated in 2017 with 25% Rodeo. This phenomenon has been observed at several other sites as well, resulting in the decision to increase the concentration of the cut-stump herbicide mixture from 25% to 33% Rodeo. Follow-up visits in summer 2019 will reveal if this concentration increase reduces the incidence of re-sprouting from treated stumps.

The overall percent cover of glossy buckthorn (both vegetative and reproductive) decreased by an average of 21%. This reflects the fact that even though the vegetative stem count increased, these stems were mostly smaller individuals that hadn't had enough growth time to make up for the canopy removed during the 2017 initial attack. All in all the numbers show promising results from the first year of treatment.

Table 8: Average stem counts (vegetative and reproductive) and percent cover of glossy buckthorn for Canon Brook Transects 1 - 4, 2017 and 2018.

	Non-fruiting Stems / m2				
	Transect 1	Transect 2	Transect 3	Transect 4	**Average**
2017	2.68	9.18	4.74	2.29	4.73
2018	3.70	22.56	5.32	3.39	8.74
	Fruiting Stems / m2				
	Transect 1	Transect 2	Transect 3	Transect 4	**Average**
2017	0.22	1.4	0.26	1.73	0.9
2018	0.04	0.24	0.14	0.84	0.31
	Percent Cover Class / m2				
	Transect 1	Transect 2	Transect 3	Transect 4	**Average**
2017	1.28	3.52	1.5	2.04	2.09
2018	0.84	2.96	1.26	1.90	1.74

Table 9: Changes in average stem counts (vegetative and reproductive) and percent cover of glossy buckthorn for Canon Brook Transects 1 - 4, 2017 and 2018.

	Non-fruiting Stems/m2	% Increase	Fruiting Stems/m2	% Decrease	Percent Cover Class/m2	% Decrease
Transect 1	1.02	38%	-0.18	82%	-0.44	46%
Transect 2	13.38	146%	-1.16	83%	-0.56	16%
Transect 3	0.58	12%	-0.12	46%	-0.24	16%
Transect 4	1.10	48%	-0.89	51%	-0.14	7%
Average	4.02	61%	-0.59	66%	-0.34	21%

Kebo Brook

The Kebo Brook site was discovered in 2017 while conducting surveys along the stream banks. Large mature stands of glossy buckthorn were located just south of the Park Loop Road, and scattered individuals followed the brook north to the private boundary at the Kebo Valley Golf Course. All mature buckthorn found were cut-stump treated in 2017, so in 2018 the EPMT returned to foliar treat the smaller plants remaining. Surprisingly, the stream corridor south of the Loop Road was covered with a carpet of germinants (see **Figure 31** below). This was where the largest number of mature plants had been removed, but the extent of the regeneration was unexpected, and may be partially due to new beaver activity which completely dried out the stream. The decision was made to not foliar spray the small plants carpeting the stream bed. The thought was that most of these would not survive due to future flooding and competition, and that it would be revisited in 2019 with any remaining plants sprayed then, reducing work hours and herbicide volume. All other glossy buckthorn on the shores of the brook and further downstream were fully treated in 2018 as well as a couple barberry and multiflora rose.

Figure 31. A large number of glossy buckthorn germinants in the Kebo Brook channel, 29 August 2018. NPS Photo

Greater Cromwell Brook Watershed

Great Meadow Unit 6

Returning to Great Meadow Unit 6 raised some important questions during the 2018 treatment season. The EPMT was surprised to find that, in spite of being treated in 2017, the historically dense stand of glossy buckthorn to the west of the Jesup Path and south of the "Burn Vista" (Motor Road Vista #56) was thriving and producing large amounts of seed (see **Figure 32** below). "Initial attack" cut-stump efforts were completed in this area years ago, so most of the remaining specimens are either stump sprouts or newly-germinated growth from the seed bank. The treatments in 2017 were primarily foliar applications to reduce this growth. Most of the buckthorn found in 2018 was at least waist high, with many individuals up to head height and taller. This implies that perhaps the foliar treatments from 2017 were not effective for some reason, and most individuals were three or four years old. The EPMT completed a thorough re-treatment of this area in 2018, using foliar herbicide applications after taller individuals were cut-stumped.

Figure 32. A dense patch of new glossy buckthorn growth and re-sprouts in Great Meadow Unit Six, 19 June 2018. NPS Photo

This experience emphasizes the need for annual follow-up visits to areas with dense populations to ensure treatments were effective. It is possible that the herbicide used in 2017 was rendered ineffective for some reason; perhaps it was too early in the season, or the chemical itself was old and not working as it should. Post-treatment checks on these dense populations, preferably within the same growing season if possible, will allow the EPMT to re-treat if the initial treatments were ineffective. A more systematic procedure for follow-up visits was initiated in 2018, with standardized monitoring forms to document treatment efficacy. This will help inform future treatments as we compile lessons learned and incorporate them into our planning process.

Another area of Unit 6, Motor Road Vista #56 (a.k.a., the "Bottling Plant Vista" or "Burn Vista") is the site of four glossy buckthorn monitoring transects. These were established by the EPMT in 2016 to monitor the effects of fire on buckthorn growth, as this vista is on a cyclic burn regime

by the Acadia Fire Program. Because this area has also been treated with herbicide by the EPMT since the first burn in 2016, the numbers reflect both fire and herbicide effects. **Table 10** below shows glossy buckthorn vegetative stem counts for each transect in the years 2016 to 2018. Average vegetative stem count has decreased every year since 2016. This implies that perhaps fire is moderately effective at suppressing smaller buckthorn specimens that have yet to reach reproductive maturity.

	Transect				
Year	1	2	3	4	Average
2016	9	81	271	110	**118**
2017	3	69	123	39	**59**
2018	8	54	79	50	**48**

Table 10. Vegetative glossy buckthorn stem counts in the Bottling Plant Vista transects, 2016 - 2018.

Table 11 below shows the reproductive stem counts for each transect in the years 2016 to 2018. Average reproductive stem count decreased sharply between 2016 and 2017, and then showed a moderate increase for 2018. This increase is likely explained by the fact that the prescribed burn here did not burn very hot, thus allowing the more mature reproductive specimens to survive because they had sufficient energy reserves to continue metabolic processes even after some of their stems were burned.

	Transect				
Year	1	2	3	4	Average
2016	3	7	19	0	**7.25**
2017	0	3	0	0	**0.75**
2018	0	5	4	0	**2.25**

Table 11. Reproductive glossy buckthorn stem counts in the Bottling Plant Vista transects, 2016 - 2018.

Table 12 below shows the average percent cover class of glossy buckthorn (both vegetative and reproductive) for each transect in 2017 and 2018 (accurate numbers are not available for 2016). Based on these numbers the prescribed burning had no overall effect on percent cover of glossy buckthorn in this area, at least between 2016 and 2017.

	Transect				
Year	1	2	3	4	Average
2017	0.16	1.7	1.39	0.48	0.93
2018	0.29	1.26	1.29	0.91	0.94

Table 12. Average glossy buckthorn percent cover class* per Bottling Plant Vista transect, 2017 - 2018.
**percent cover classes: (0) = 0% cover; (1) = <1% cover; (2) = 1-5%; (3) = 5-10%; (4) = 10-25%; (5) = 25-50%; (6) = 50-75%; (7) = 75-95%; (8) = 95-100%*

Other Cromwell Brook Units

A number of other units were visited in the greater Cromwell Brook watershed in 2018. Unit 3, which begins east of the Jesup Path and ends where the open meadow begins, saw its first round of follow-up foliar treatment in 2016 after an intensive initial attack phase in 2015. 2018 saw the completion of a second round of foliar treatments for this area. Many sections of Unit 3 were nearly 100% covered with immature glossy buckthorn. Some were seedlings and germinants that had sprouted within the last two growing seasons, while others were re-sprouts from previously cut and treated stumps. As mentioned in the Canon Brook narrative, the high incidence of sprouting from treated stumps led the EPMT to switch from 25% to 33% Rodeo for its cut-stump applications. Monitoring visits in 2019 will show if this increase was enough to bolster treatment efficacy.

In addition to tight gridding done in the forested area just east of the Jesup Path, where glossy buckthorn continues to dominate the understory, extensive surveys and treatments were completed in the Unit 3 "transition zone" between forest and open meadow. This area is dominated by waist-high shrubs (e.g., rhodora [*Rhododendron canadense*], sweetgale [*Myrica gale*], bayberry [*Morella caroliniensis*], leatherleaf [*Chamaedaphne calyculata*], and Labrador tea [*Rhododendron groenlandicum*]), mixed with sporadic larch and hardwoods. Glossy buckthorn is widely dispersed throughout this zone, which more or less forms a belt around the entirety of the open meadow. Under trees, the density is heavier due to bird dispersal of seeds as they perch on the branches above. Much of this area had been treated in 2016, but additional large swaths were covered that had never seen treatment, particularly closer to where the meadow opens up completely. As suspected, the abundance of direct sunlight in this area allows buckthorn specimens of a much smaller stature (i.e., waist height and below) to produce mature fruit. For this reason thorough gridding is required in these more open areas, as opposed to merely seeking and destroying taller fruiting individuals that rise above the shrub layer.

Foliar treatments were also carried out in Unit 1 (south end of The Tarn, also called Route 3/Tarn), Unit 4 (area to the west of the Jesup Path and east of the Hemlock Road), Unit 7 (the Harden Farm area), and Unit 11 (between Route 3 and the Park Loop Road south of the old road bed leading from the Jackson Lab campus). Parts of Unit 12 (the Beaver Dam Pond outflow toward the Jackson Lab campus) were revisited for a mixture of cut-stump and foliar applications. Parts of Unit 18, which makes up the entirety of the open meadow, were also surveyed and treated for the first time. There are a number of "peninsulas" of slightly higher

(and thus dryer) ground that jut out into the open area near the Sieur de Monts parking lot; these were surveyed and cut-stump treatments were performed on the numerous large fruiting individuals found. These peninsulas will need foliar revisits in 2019. The main channel of the Great Meadow (most of which lies within Unit 18) was also surveyed in its entirety, with only one or two buckthorn specimens found in the middle of the open area.

Glossy buckthorn target areas for 2019 in the greater Cromwell Brook watershed include:

- Unit 6 and any others last visited in 2017 for a monitoring follow-up and potential re-treatment depending on extent of buckthorn regeneration;
- Parts of Unit 12 in and around the Beaver Dam Pond outflow (a.k.a. Bear Brook)
- Parts of Unit 14, particularly bordering the Park Loop Road as well as a focus on the denser population that starts near the intersection with Ledgelawn Extension (a.k.a. Great Meadow Drive) and continues up the drainage toward the top of Strawberry Hill;
- Unit 15, particularly the inflow to Beaver Dam Pond in which heavy concentrations of fruiting individuals were found in 2018, but also the area surrounding the historically dense (but relatively small) patch near the southwestern corner of where Route 3 passes over the Park Loop Road;
- Unit 16 (Sieur de Monts and immediate surroundings); and
- The peninsulas in Unit 18 for follow-up foliar treatments.

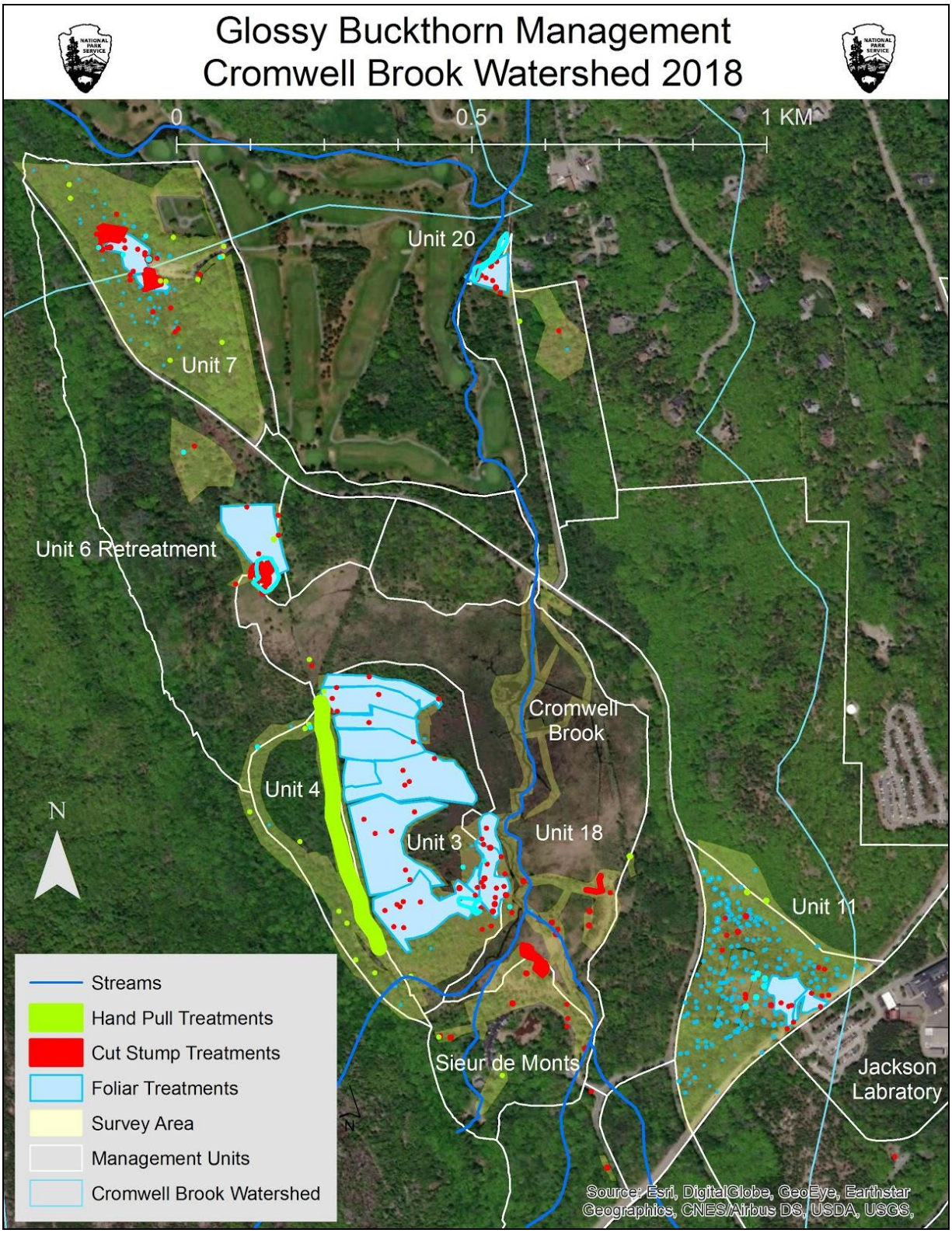

Figure 33. Glossy buckthorn management activities in the greater Cromwell Brook watershed in 2018.

Collaborations, Partnerships, and Outreach

In 2018 the EPMT continued to develop and maintain partnerships with Friends of Acadia (FOA), Schoodic Institute, College of the Atlantic, Maine Coast Heritage Trust, Maine Department of Agriculture, Conservation, and Forestry, US Forest Service, Animal and Plant Health Inspection Service (APHIS), Jackson Laboratory, Somes-Meynell Wildlife Sanctuary, Mount Desert Land & Garden Preserve, and the Maine Invasive Species Network to protect native plants.

Furthermore, we continued active involvement with the Terrestrial Invasive Plant Scientific Advisory Committee, a state wide effort comprised of professionals around the state of Maine involved with invasive plant management, research and education. The committee focused on evaluating the Species Ranking Assessment and Screening Process of invasive plants for the state of Maine.

On June 13, 2018 the EPMT conducted a joint "herbicide boot camp" training with staff from Maine Coast Heritage Trust (MCHT) and the Maine Natural Areas Program (MNAP). Content covered included safe herbicide use (mixing, handling, storage, transportation, and application), emergency spill response, invasive plant identification, effective scouting strategies, proper herbicide treatment methods, herbicide use reporting, and data collection / management. This day-long training was conducted at two locations: the MCHT "Barn" at the Babson Creek Preserve in Somesville for the morning, and Lamoine State Park for the afternoon. The sessions at the Barn consisted of indoor lecture-style presentations as well as outdoor hands-on practical demonstrations of proper herbicide mixing, loading, handling, application, and transportation (see **Figure 34** below). The session at Lamoine State Park involved active surveying and treatment of invasive exotic plant populations in a given area, designed as a "learn by doing" exercise with opportunities for coaching and feedback throughout the exercise and an end-of-session wrap-up discussion (see **Figure 35** below).

Figure 34. Jesse Wheeler gives an overview of the EPMT's truck setup for herbicide storage and transportation during the joint training with MCHT and MNAP, 13 June 2018. This portion of the training was held at the MCHT Barn in Somesville. NPS Photo

Figure 35. Nick Stevenson and Jim Burka work with Nancy Olmsted (MNAP) and others during a hands-on field exercise during the joint training with MCHT and MNAP, 13 June 2018. This portion of the training was held at Lamoine State Park. NPS Photo

Coordination with staff at the Land and Garden Preserve (LGP) continued in 2018. Unlike 2017, there were no joint work days between the EPMT and LGP landscape staff. However Jesse maintained communication with LGP management about ongoing invasive survey and treatment efforts. LGP landscape staff actively managed glossy buckthorn on their property, thus helping prevent the spread of this population onto nearby park lands. The EPMT surveyed two areas of concern along the ANP-LGP boundary line: Jordan Stream between the Jordan Pond outflow and the wetland area at the northern end of Little Long Pond, as well as Little Harbor Brook between the Little Harbor Brook carriage road bridge and the first mature buckthorn individual found (which was well within LGP property). These stream corridors were found to be relatively clean from their northern reaches on ANP land until well onto LGP property. These findings were communicated to LGP staff and will help inform their treatment efforts in 2019. Tentative plans have been made for more joint ANP-LGP invasive treatment work days in Summer 2019. Nick and Jesse also coordinated with Tate Bushell on the use of the ESRI Collector application on tablet devices. It is hoped that this will facilitate information sharing between ANP and LGP on invasive plant management.

In 2018 the EPMT also increased public outreach and education on invasive species with presentations to the Ellsworth Garden Club, Mount Desert Garden Club, College of the Atlantic, Mount Desert Invasive Species Forum, the Isle au Haut community, and at resource sessions for NPS staff and volunteers.

The EPMT attended two professional conferences in 2018: the 8th Maine Invasive Species Network (MISN) Annual Meeting held at the Maple Hill Inn and Conference Center in Hallowell, Maine on March 16, and the Acadia Science Symposium held at College of the Atlantic on October 20. Both conferences included presentations by land management experts from Maine and other parts of New England. The EPMT created and presented a poster for the poster session at both conferences. The MISN poster focused on the initial stages of Norway

maple management (i.e., the treatments in and around the seven treatment plots at Compass Harbor, Duck Brook, and Ledgelawn). For the Science Symposium the EPMT was able to present an updated poster with findings on how these initial treatments are beginning to change the characteristics of the Norway maple forest, since the second annual Norway maple forest plot assessments had been completed and analyzed by that time.

Invasive Aquatic Plants

Acadia National Park and Somes-Meynell Wildlife Sanctuary teamed up for the third consecutive year with Lake Stewards of Maine (LSM; formerly the Maine Volunteer Lake Monitoring Program, or VLMP) to search for Invasive Aquatic Plants (IAPs) on MDI. No invasive aquatic plant or animal species were found, which is very good news! Experienced Invasive Plant Patrollers from all over Maine, LSM, ANP, Land and Garden Preserve, Somes-Meynell Sanctuary staff, and local volunteers conducted the surveys. Patrollers searched the entire littoral zone (where light can reach the bottom of the lake and rotted plants can grow, typically the entire perimeter in addition to other shallow areas) of Jordan Pond (see **Figure 36** below), Witch Hole Pond, Lakewood, Seal Cove Pond (south end), Bubble Pond, Aunt Betty Pond, Upper and Lower Breakneck Ponds (see **Figure 37** below), Beaver Dam Pond, The Tarn, and the pond's end area of Great Long Pond.

Figure 36. LSM Invasive Plant Patrollers survey Jordan Pond for invasive aquatic plants, 9 September 2018. NPS Photo

Figure 37. ANP Volunteer Sherri Latulippe works with LSM Invasive Plant Patrollers to identify an aquatic plant found in Lower Breakneck Pond, 8 September 2018. NPS Photo

Cultural Vegetation Management – Historic Vistas and Roads

As in previous years, in 2018 the EPMT assisted Acadia's Maintenance Department with tree work for a wide variety of projects throughout the park. This interdivisional partnership began in fall 2014 in an effort to provide winter employment for EPMT members, as well as to facilitate the exchange of ideas between employees from different backgrounds. EPMT members working on the Maintenance cutting crews have learned volumes about tree felling techniques, mechanical operations (ranging from light-duty equipment like capstan winches and Kubotas to heavy equipment like chippers and backhoes), and safe use of chainsaws during felling, brushing, limbing and bucking. EPMT members also offer a Resource Management perspective as on-the-ground decisions are made on the best way to accomplish the goals of these various winter cutting operations. In addition to EPMT members, the winter cutting crews also include members from other park divisions such as Fire, Trails, and Law Enforcement, which adds further fresh perspectives.

The main cutting project for winter 2018 was to prepare for the Isle au Haut Loop Road rehabilitation scheduled for summer 2018. All trees within 8 feet of the road's centerline were removed to allow for movement of heavy equipment during filling, grading and culvert replacement later in the year. Housing for the cutting crew was secured at the former location of the Black Dinah Chocolatier, south of the ranger station in town. EPMT members Alex Fetgatter and Nick Stevenson spent every other week helping with the cutting operations there, taking the ferry from Stonington on Monday morning and leaving Isle au Haut Thursday afternoon. Three nights of almost every other week from December 2017 through mid-April 2018 were spent out

on the island. As illustrated in **Figure 38** below, burning was a crucial means of dealing with the mass of slash generated during the cutting of roughly four miles of roadside.

Figure 38. Dave Smith (Law Enforcement) and Reino Liimatainen (Maintenance) light a brush pile on the side of the Isle au Haut Loop Road, 7 February 2018. NPS Photo

Other cutting projects during winter 2018 included clearing of trees and brush from coping stones and drainage ditches along the upper portion of the Cadillac Mountain summit road. Crews limbed and removed hazard trees along the Park Loop Road from the Sand Beach entrance station to Jordan Pond, Blackwoods and Seawall Campgrounds, and cutting of hazardous dead standing red pines (*Pinus resinosa*) killed by red pine scale (*Matsucoccus matsumarae* [Kuwana]) along portions of Paradise Hill Road. All materials generated from red pine cutting (tree boles, limbs, and any chipped materials) were left in the immediate area to minimize the spread of this invasive insect (see **Figure 39** below for an example of this method at another site). The risk of spread is further reduced by only cutting these trees during the colder months, as red pine scale is dormant during this time.

Figure 39. Red pine hazard tree mitigation, just west of Carriage Road Intersection #7, 16 November 2017. NPS Photo

Native Plant Restoration and Research Assistance

As in 2016 and 2017, the EPMT assisted the New England Wildflower Society (NEWFS) in planting native plants into new research test beds filled with weed-free soil on the Cadillac Mountain summit. The group filled newly selected restoration areas with sterilized soil (instead of bagged commercial compost) and planted with modules and plugs of native plants grown from seed at NEWFS' Nasami Farms in Framingham, Massachusetts (see **Figures 40** and **41** below). The restoration areas were selected from social trails that bisected existing vegetation and extensions of vegetated islands. The team hopes to learn if adding 4-6 inches of soil to degraded areas of bedrock will provide good growing conditions for native plants on top of Cadillac Mountain.

Soil for this work in 2018 was sterilized at Park Headquarters in the Maintenance gym using an electric soil sterilizer purchased by NEWFS for this purpose. This piece of equipment will stay at the Park, so EPMT staff may put it to use in the future when preparing beds for other revegetation projects.

Figure 40. Alex Fetgatter, Jesse Wheeler, Jim Burka, Jill Weber, and Bill Brumback (NEWFS) plant plugs of various native plants in a roped-off area within the summit loop trail on the summit of Cadillac Mountain, 12 June 2018. NPS Photo

Figure 41. Nick Stevenson and Jill Weber haul sterilized soil to a new revegetation plot near the bus parking lane on the Cadillac Mountain summit, 31 October 2018. NPS Photo

The EPMT also surveyed carriage road ditches between intersections 14 and 10 for invasive and rare plants ahead of scheduled ditch cleaning by Maintenance crews. In addition to locating and treating Asiatic bittersweet, the crew documented the uncommon native vine, *Clematis virginiana*, growing on a retaining wall. Prior to the ditch cleaning along this stretch of carriage road the crew salvaged mayflower (*Epigaea repens*), American mountain-ash (*Sorbus americana*), and mountain holly (*Ilex mucronata*) for transplanting at the Wild Gardens of Acadia.

Treatment Summary

The following summarizes the exotic plant management work completed by Acadia National Park's EPMT in 2018.

Total Infested Acres Treated	**3.92***
Total Acres Surveyed	**1,149**
Total EPMT Work Hours	**1,685**
Total Volunteer Work Hours	**54.5**
Number of Species Treated	**27**
Estimated Program Costs (Fiscal Year 2018)	**$295,948**

**{Infested acres are defined as total area of leaf canopy cover of invasive plant species at 100% density. In other words, this figure represents the total acreage that would be covered if the entire leaf canopy cover of all treated invasive exotic plants were gathered together at 100% density.}*

Herbicides Used in 2018

Herbicide*	Treated (Infested) Acres	Herbicide Concentrate Used (oz.)
Garlon 4 Ultra®	0.62	35.90
Pathfinder 2®	0.06	12.20
Garlon 3A®	0.11	23.25
Milestone®	0.17	5.33
Rodeo®	2.79	848.45

* Additional information on each herbicide and how they are utilized by the EPMT can be found in the 2015 and 2016 Exotic Plant Management Annual Reports. Herbicide use by species is presented in **Tables 2** and **3** of this report. Numbers rounded to two decimals.

Table 13. Herbicides used at Acadia National Park for exotic plant management in 2018, with total acres treated and ounces of herbicide concentrate sprayed. These numbers are reported to the NPS Pesticide Use Proposal System (PUPS) on an annual basis.

Changes to Herbicide Selection and Concentration in 2018

Several changes were implemented in herbicide chemical selection and concentration in 2018. Cut-stump treatments on glossy buckthorn were changed from 25% Rodeo® to 33% Rodeo® starting 08/23/2018. This change was due to the high number of cut stump resprouts observed in the past two years. The 25% concentrate is actually much lower than label recommendations, which range from 50% to 100%. The 33% treated stumps will have to be monitored in 2019 for effectiveness.

Foliar treatments of Asiatic bittersweet switched from 3% Rodeo® to 5% Garlon 3A® mid-season. This was because 3% Rodeo was shown to achieve low kill rates both with monitored 2018 treatments, and anecdotally from past seasons. The 5% strength Garlon 3A® is also

considered standard in the restoration field for Asiatic bittersweet, and monitoring in 2018 suggested this concentration is indeed more effective.

Finally, based on recent research from other land units, a trial switch from 5% Rodeo® to 0.4 % Milestone® was implemented for Japanese knotweed foliar spraying away from water systems. The effectiveness of this change will be determined in 2019, but preliminary results looked promising. Each of these treatments could benefit from their own side-by-side herbicide comparison studies in 2019.

Program Recommendations and Objectives for 2019

- Increase field crew members from three to four (in addition to the program leader), and add an Acadia Scholar Intern if possible.
- Continue to regularly monitor and document treatments from 2018 and during the 2019 field season.
- Continue to survey all exotic plant monitoring transects and plots.
- Conduct potential herbicide comparison studies for glossy buckthorn cut-stump treatments and Asiatic bittersweet foliar treatments, and continue to evaluate the use of Milestone® for Japanese knotweed.
- Improve data collection quality through spring data training and employing multiple data loggers.
- Recruit volunteers for mechanical treatments on garlic mustard, narrowleaf bittercress, glossy buckthorn seedlings near Sieur de Monts (particularly Unit 3), and more.
- Use the early field season for foliar treatment of Japanese and common barberry shrubs.
    - Duck Brook and Paradise Hill: expand survey areas at these sites beyond the areas treated in 2018.
    - Route 3/Tarn: treat the known barberry site found halfway between Route 3 and Canon Brook.
    - Hunters Brook: there is a reported plant here, and more surveys could be conducted.
    - Bar Island: visit the northern part of the island (last treated in 2016), and also treat the steep southern slope as best as possible.
- Continue ongoing glossy buckthorn management, and expand to any new sites.
    - Kent Field North: treat the heavily invaded western side of the wetlands.
    - Canon Brook: foliar treat this site for the second time.
    - Great Meadow Units: mostly foliar treatments at numerous units – Unit 18, finish unit 3, Unit 15 (inflow to Beaver Dam Pond) where mature plants were found in 2018, the perimeter of Unit 15, part of Unit 2, and Unit 16 (Sieur de Monts); also survey and possibly manage areas last visited in 2017 – Units 20, 6, 8, 17, 10, and 19.
    - Tremont School: conduct further surveys of this area and conduct initial cut stump treatments.
    - Jackson Lab: collaborate with Lab staff and manage glossy buckthorn with both cut stump and foliar methods.
    - Survey watersheds not yet known to contain glossy buckthorn, or with unknown populations.

- Asiatic bittersweet management.
    - Sawyer's Point (Flye Farm): foliar treat the woods and meadow areas.
    - Sand Beach / Nursery: retreat the bittersweet here that did not die from 2018 foliar treatments.
- Conduct work on Acadia's outer islands.
    - Isle au Haut: visit in the spring to treat the new barberry population.
    - Sheep Porcupine: manage the honeysuckle and other woody invasives as soon as allowable, or after August 31 (when the island re-opens after bald eagle nesting).
    - Burnt and Bald Porcupine: these islands have known populations of honeysuckle and bittersweet, and should be visited and treated.
- Spend one or two days managing the known invasive sites on the Schoodic Peninsula, and survey likely areas for new infestations.
- Continue scouting areas around our border with the Land and Garden Preserve, potentially collaborating with their staff for joint treatment efforts.
    - Little Harbor Brook.
    - Jordan Stream.
- Conduct cut-stump and hack-and-squirt treatments of Norway maple sites in autumn 2019, starting with smaller satellite sites.
- Continue expanding natural and cultural landscape restoration projects, and exploring new trainings to develop diverse skills and abilities for EPMT staff.

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