



Invasive Vegetation Management

2018 Annual Report





ON THIS PAGE

Canada thistle (*Cirsium arvense*) encountered within the 2016 Bybee Creek fire perimeter.
Photo by Jen Hooke.

ON THE COVER

The Invasive Vegetation Management Crew surveys for invasive plants within the area burned by the 2016 Bybee Creek fire.
Photo by Jen Hooke.

Invasive Vegetation Management

2018 Annual Report

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

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

This report received informal peer review by a subject matter expert who was not directly involved in the collection, analysis, or reporting of the data.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

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Abstract

Work performed in 2018 by Crater Lake National Park's Invasive Vegetation Management program continued a steady 16-year effort to detect, contain, and reduce infestations of invasive plant species within the Park. A major accomplishment was implementation of the Park's new Invasive Vegetation Management Plan for its first full field season. Using manual and chemical methods an estimated 88,750 invasive plants were treated in 2018. One new-to-the-Park invasive plant species, common tansy (*Tanacetum vulgare*), was discovered along a Park roadside. Previously undetected infestations of invasive plants were found in meadows near Thousand Springs and within areas burned by recent fires. The Rim Drive Rehabilitation and Pacific Crest Trailhead well construction projects continued to bring challenges to the IVM program due to substantial ground disturbance and increased potential for invasive plant introductions.

Acknowledgments

The 2018 Invasive Vegetation Management seasonal crew at Crater Lake National Park was made possible through support provided by the U.S. Department of the Interior/National Park Service Burned Area Rehabilitation program and the National Park Service Natural Resource Cyclic Maintenance program. The Crater Lake National Park Revegetation crew provided assistance with invasive plant survey and control efforts, namely Kaylin Scott, Melody Frederic, Scott Heisler, Tara Chizinski, and Carrie Wyler. Invasive plant observations reported by other Crater Lake National Park employees were greatly appreciated and very helpful in preventing the spread of invasive plants. Chris Wayne supported data collection efforts through maintenance of a geodatabase and Trimble Juno units, and Sean Mohren assisted with database management.

Introduction

The 2018 field season marked the sixteenth year of recurring management of non-native, invasive plant species within Crater Lake National Park (CRLA). Invasive species are widely recognized as being one of the largest threats to natural areas; as such, the National Park Service (NPS) has been charged with preventing the introduction of non-native, invasive plant species and controlling infestations of invasive plants where they have become established (USDI NPS 2006). Responding quickly to new invasions (Figure 1) and controlling existing infestations of invasive plants are important functions of CRLA's Invasive Vegetation Management (IVM) program.

Due to its high elevation position spanning the Cascade crest, its abundant snowfall, and its limited disturbance history (excluding the large fires of the last four years), CRLA has been better protected against invasion by non-native plant species than other NPS units. The IVM program at CRLA is tasked with upholding and improving this unique status.

The goals of the IVM program are as follows:

1. *Prevention*: prevent the introduction and spread of invasive plant species within CRLA.

2. *Early Detection and Rapid Response*: survey for new invasive plant infestations to allow for swift treatment and control.

3. *Effective Control*: control invasive plant species within the Park through eradication, containment, and reduction of invasive plant population densities and abundance. Utilize an adaptive management framework based on the best available science and current knowledge to determine the most effective and appropriate treatment options for proactively controlling invasive plant species.

4. *Monitoring and Data Management*: monitor treatment efficacy, and use results of monitoring to inform management.

Manage invasive vegetation data to enable regular reporting of results and progress.



Figure 1. IVM crew member treating invasive plants with herbicide within the Spruce Lake Fire area. Photo by Alissa Iverson.

5. *Outreach and Education*: educate and inform the Park’s visitors, employees, and partners on the Park’s IVM program and involve them in prevention, control, and monitoring efforts.

6. *Collaboration*: communicate regularly with Park partners, including other federal, state, and county entities, and collaborate on invasive vegetation management and control.

The 2018 IVM field season was notable for a few reasons. The crew consisted of five individuals, which was the smallest field crew since 2015. This was due to issues with seasonal hiring (e.g., delays in getting lists of qualified applicants; difficulty finding interested applicants for the positions) and receiving funding too late to survey and treat the area burned by the 2015 National Creek Complex of fires. In late July 2017, the IVM program implemented a new Invasive Vegetation Management Plan (USDI NPS 2017), which included chemical treatment methods that allowed for rapid and effective treatment of previously time consuming and difficult-to-control invasive plant species. The 2018 season was the first full field season operating under the new plan.

Several events occurred during the 2018 field season that impacted the activities of the IVM crew. After 2016—2017’s above-average snowfall, CRLA received 336 inches of snow from October 1, 2017 to September 30, 2018 which is 65.7% of average (the average is 512 inches). The first snow-

free day at Park headquarters was May 28th, compared to July 4th in 2017 and June 13th in 2016 (average date is June 18th). This early snowmelt jumpstarted the field season and allowed work to begin earlier than in 2017. The Park installed a new well to support public water use in 2017 at the Pacific Crest Trail parking area and installed a new waterline along Highway 62 connecting the well to existing infrastructure, resulting in significant roadside (Figure 2) and interior disturbance. Several fires burned the northeast corner of the park with Timber Crater 6 and Timber Crater 10 being the most significant. Both fires started in mid- to late-July and the smoke associated with these and other fires in the region drastically reduced air quality and occasionally forced cessation of field work.



Figure 2. Roadside soil and vegetation disturbance resulting from construction of a new well and waterline. Photo by Jen Hooke.

The majority of invasive plants in CRLA are found along roadsides and in backcountry areas. Funding was received from the Department of the Interior/National Park Service Burned Area Rehabilitation (BAR) program to survey for and control invasive plants within the areas impacted by the 2016 Bybee Creek fire and the 2017 Blanket Creek and Spruce Lake (Figure 3) fires. Areas

targeted for invasive plant survey and control efforts included firelines, aerial fire retardant application zones, spike camps, and helispots. Another funding source for the 2018 IVM program was the NPS Natural Resource Cyclic Maintenance program, which funded survey and treatment of invasive plant species in and adjacent to facilities such as roads, buildings, and trails. This enhanced the aesthetic qualities of the landscapes surrounding these facilities and prolonged their lifespan by reducing the need to control aggressively spreading invasive vegetation.



Figure 3. IVM crew member surveying for invasive plants in an area burned by the 2017 Spruce Lake fire. Photo by J.C. McNelly.

Methods

Crater Lake has been divided into five IVM Zones (Backcountry, Developed Areas, Lakeshore, Roadside, and Staging Areas) and these zones are subdivided into IVM regions where survey and control efforts are targeted. Each region is a “problem area” where invasive plants are known to be concentrated, have recently been detected, or have a high probability of becoming established. The control strategy for each region varies depending upon which invasive plant species it contains as well as terrain and other biological considerations. General control strategies for invasive plant

species are containment – preventing new infestations and spread; reduction – reducing the size and extent of existing infestations; and eradication – extirpating the plant species from the Park.

Non-native plant species are given a management priority of high, medium, low, or watch. All high priority species are actively targeted for control efforts; medium priority species are targeted as time and resources allow. Low priority species are usually not targeted for management, either because populations of those species are not aggressively spreading or populations are beyond control. Watch species are those that have been documented within the Park, but have not been observed in >10 years, or species that are found outside of and proximal to the Park. If any watch species are found within the Park, they receive a management priority of high. These management priorities may change depending upon situation and location. For example, a low priority species may be controlled if found in a pristine wilderness environment and its control is feasible. A high priority species may not be treated in a specific region where its population is beyond control. Low priority species may be controlled concurrently at sites where high priority species are being treated.

Vegetation surveys consist of visually searching a region for invasive plants (Figure 4), typically on foot but occasionally via boat or automobile. The IVM crew navigates to known invasive plant

locations with the aid of GPS units, and in most instances uses a grid formation to survey for invasive plants. This entails the crew lining up and spacing out so there are no gaps in the field of vision between crew members; this can vary based on terrain and vegetation structure. The line is led by a crew member on the end, who navigates with a GPS unit, and as crew members visually search the area for weeds they follow the direction of the end person, keeping equal spacing between one another. The crew conducts multiple transects in this manner depending on the



Figure 4. Surveying for invasive plants within the Sphagnum Bog Research Natural Area. Photo by Jen Hooke.

extent of historic and contemporary weed populations. In previously unsurveyed areas with no record of invasive plant species, surveys are concentrated on the most likely establishment points, such as open habitats, areas with moist soils or close to water, and recently disturbed habitats. Based on prior experience, it is unlikely to find invasive plant species in dense, closed canopy forests at CRLA.

Once an invasive plant population is discovered, data are recorded including scientific name, UTM coordinates (Zone 10, NAD83 datum), total number of plants present, area that plants occupy (m²), and treatment applied to the population. Data are input (Figure 5) into a Trimble Juno field computer using ArcPad software. Plants are either pulled from the soil intact using Hori-Hori digging knives, or sprayed with herbicide via a backpack or hand sprayer. When manual treatments are used, all plant parts capable of reproduction (e.g., inflorescences in the case of plants that reproduce via seed, and rhizomes/corms/tubers for pulled plants capable of vegetative reproduction) are bagged, removed from the site, and disposed of in the trash compactor at Park headquarters where they are hauled in a closed truck to the Dry Creek Landfill in White City, Oregon, for burial. Vegetative parts incapable of reproduction are left to desiccate on site unless they present logistical or aesthetic problems for Park visitors, employees, and partners.

When possible, any new-to-CRLA non-native plant species encountered are collected as voucher specimens for the Park's herbarium. Often only one or two individuals are discovered and are



Figure 5. Field data entry using Trimble Juno units to record invasive plant occurrence and treatment. Photo by Alissa Iverson.

destroyed during the plant identification process, so vouchering may not be possible. Non-native plants encountered in previously undocumented locations within the Park are also collected for the Park's herbarium.

Crew members carry a booklet containing images and descriptions of the known non-native plant species in CRLA. This booklet is often sufficient for identifying unknown plants in the field, and is updated regularly for accuracy

and the inclusion of new weed species. If plant specimens found during surveys are not identified in the field, they are bagged and taken back to the office for keying and possible voucher creation. The population location is mapped with a GPS unit and the plant species is entered as 'Unknown' in the database and assigned a unique code. The plant is identified immediately before desiccation or decomposition occurs, and if necessary, a voucher specimen is created. Plants that cannot be identified the day of collection are placed in a specimen refrigerator for preservation. Once the plant

is identified, the plant species name is changed from ‘Unknown’ to the correct species code in ArcPad or the IVM database.

After the Invasive Vegetation Management Plan was approved in July 2017, the IVM crew started using herbicide as a treatment option. Ten herbicides were approved for use in the Park, with four herbicides submitted and approved for use through the NPS Pesticide Use Permitting System (PUPS) in 2017 (Table 1). The same four herbicides were used in 2018: Roundup ProMax, Roundup Custom, Milestone, and Transline (for use only along non-aquatic rights of way).

Table 1. Herbicides approved for use under the CRLA Invasive Vegetation Management Plan Environmental Assessment. Bold type indicates herbicides approved for use in 2018 through the NPS PUPS.

Herbicide	Trade Name	Treatment Type	Use Areas
Aminopyralid	Milestone	Pre- and post-emergence	Terrestrial to water's edge
Chlorsulfuron	Telar	Pre- and post-emergence	Terrestrial
Clopyralid	Transline	Pre- and post-emergence	Terrestrial, right of way only
Glyphosate	Roundup ProMax, Roundup Custom	Post-emergence	Terrestrial and Aquatic formulations
Imazapic	Plateau	Pre- and post-emergence	Terrestrial
Imazapyr	Arsenal, Habitat, Stalker	Pre- and post-emergence	Terrestrial and Aquatic formulations
Metsulfuron	Escort	Pre- and post-emergence	Terrestrial
Rimsulfuron	Matrix	Pre-emergence	Terrestrial
Sulfometuron	Oust	Pre-emergence	Terrestrial
Triclopyr	Garlon	Post-emergence	Terrestrial and Aquatic formulations

Botany staff obtained Oregon state public pesticide applicator's licenses with regulatory weed categories. Secure storage facilities were maintained for herbicide and spray equipment, with spill kits staged at each storage site including vehicles. Each day herbicide use was expected, site-specific historic invasive plant data were reviewed. That information along with site-specific factors determined the amount and type of herbicide that was brought into the field. Herbicide concentrate was mixed and loaded into spray equipment at appropriate concentrations, then loaded into a truck bed for transport to the site. Occasionally a small bottle of herbicide concentrate would be transported to the field in a truck lockbox if the need to mix more herbicide formulation was anticipated. The crew utilized both backpack and hand sprayers. Backpack sprayers are more traditionally used for herbicide application; however, CRLA contains very few invasive plant monocultures, thus hand sprayers generally have sufficient capacity. Hand sprayers have the advantage of being far more portable than backpack sprayers, and allow the applicator to carry a normal backpack while working.

When leaving the vehicle and gearing up for the field, hand sprayers are typically placed in dry bags and attached to backpacks for transport to the field site (Figure 6). If backpack sprayers are used,

one or two people may be designated to carry water, food, and a first aid kit to support the herbicide applicators. These individuals are also responsible for inputting data into the Trimble Juno units, as well as navigation. Any herbicide left behind is locked in a box in the truck bed.

When invasive plants are found, the vegetative parts are sprayed with care to avoid spraying non-target species, as well as to minimize herbicide drift. Inflorescences may be collected as they can disseminate seeds before the herbicide is effective, but rhizomes are left intact for herbicide translocation throughout the plant. In the event of late-season spraying, leaves may be losing chlorophyll and turning red. In this case, plants are not sprayed. Care is also taken to avoid spraying in wind, on snow, early in the morning when leaves are covered in dew, and before forecasted precipitation. Weather forecasts are checked for rain, strong winds, and lightning before each field day.

Data collection for herbicide treatment is almost identical to data entry when treating with manual methods. However, additional data are required to be maintained as per Oregon Department of Agriculture (ODA) regulations including treatment beginning and ending time, amount of herbicide used (ounces per acre), and full names and license numbers of all applicators. The ODA data are recorded and later scanned into electronic records. Herbicide treatment records are then kept for a minimum of three years as per state regulations.



Figure 6. Hand sprayers are transported to the field in dry bags (orange) attached to the outside of field packs. Photo by Jen Hooke.

Results

Invasive vegetation survey and control work occurred from April 30 – October 25, 2018. Approximately 88,750 invasive plants were controlled during the 2018 field season, including one non-native plant species that had not been previously recorded within CRLA: common tansy (*Tanacetum vulgare*) that was found along a Park roadside. This brings the number of non-native plant species documented within CRLA to 89. Control efforts put forth by the 2018 IVM program

are presented by general IVM zones. Data displayed on the following maps indicate the number of invasive plants found and treated during the 2018 season.

Backcountry Zone

The Park's backcountry zone includes any areas away from roads, developed areas, staging areas, and the Crater Lake shoreline. A total of 48,683 invasive plants were treated in the Park's backcountry areas during the 2018 field season (Figure 10; Tables 2 and 3). The western half of the Park receives more precipitation from incoming Pacific storms than does the east side of the Park due to orographic effects; additionally there is a history of grazing in some of the recent (1980s) additions to the Park's westernmost border. Due to these factors, the west side of the Park generally harbors more invasive plant infestations than the east side.

Much of the western half of the Park burned during the 2015—2017 fire seasons. The Park's 2018 fire season was quieter, with large fires occurring near Timber Crater in the far northeastern portion of the Park. Fire closures did not significantly affect IVM work in 2018. Most of the western part of the Park was closed during August and September of 2017 due to the Spruce Lake and Blanket Creek fires, which unfortunately hampered the IVM crew's ability to survey areas burned in 2015 and 2016. Recently burned areas were areas of focus for the 2018 IVM crew (Figure 7).



Figure 7. Left: Surveying for invasive plants in a heavily impacted helispot within the 2017 Spruce Lake fire perimeter. Photo by J.C. McNelly. Right: Preparing to treat a small Canada thistle population in the 2017 Spruce Lake fire area. Photo by Alissa Iverson.

The Red Blanket Canyon continued to be a hotspot for invasive plant infestations. This area encompasses the Park's lowest elevation (3,900') and contains one of the Park's most diverse floras. The area is characterized by very steep, rugged terrain that presents challenges for IVM work. Most of this area burned in the 2008 Middlefork Fire of the Lonesome Complex; the upper part of this area was reburned by the 2017 Blanket Creek fire (Figure 8). In 2018, the IVM crew visited the Red

Blanket Canyon area several times, resulting in treatment of 4,852 invasive plants; the majority of plants treated were bull thistle (*Cirsium vulgare*), woodland groundsel (*Senecio sylvaticus*), and flannel mullein (*Verbascum thapsus*). Tansy ragwort (*Senecio jacobaea*) was encountered in the Red Blanket Canyon for the first time in 2018. The Red Blanket Canyon harbors the Park's only known backcountry cheat grass (*Bromus tectorum*) infestation. Cheat grass was discovered in 2015 and manually removed in 2015 and 2016, but was unable to be treated during the 2017 field season due to wildland fire area closures. No infestations were found during 2018; however, historic sites should be revisited in the future to ensure eradication.



Figure 8. Areas of the Red Blanket Canyon have burned twice in the last decade; these are target areas for invasive plant survey work. Photo by J.C. McNelly.

Within the area burned by the Crescent Fire of the 2015 National Creek Complex, a total of 1,147 invasive plants were treated during 2018. Many invasive plants were found within the boundaries of the 2001 Border and 2009 Desert Ridge fires that were encompassed by the National Creek Complex. This illustrates the importance of surveying areas that have experienced multiple fires several times in a field season as they seem to harbor established invasive plant seedbeds. Invasive plants were also found within the

2016 Bybee Creek and 2017 Spruce Lake fires, but infestations were patchy and small. Areas impacted by fire suppression activities (e.g., firelines, helispots, spike camps, retardant drops) were targeted for invasive plant surveys. Surveying required careful searching to detect invasive plant infestations that were just becoming established.

The 2008 Castle fire continues to be a problem area for invasive plant infestations. Many thistle populations are established in this area. Additionally, a large infestation of wall lettuce (*Mycelis muralis*) was found in the Castle fire in 2018. The entire fire area should be surveyed in 2019; some areas were missed in 2018 especially towards the eastern part of the fire. Two small fires (Deer and Dump) that were part of the 2014 Pumice Complex of fires are located just south of the Castle fire; they were surveyed in 2018 and no invasive plants were found.

Meadow and wetland systems surveyed in 2018 include Poison Meadows, Thousand Springs, Sphagnum Bog, Spruce Lake, and the Panhandle's Cottonwood Meadows. No invasive plants were found at Spruce Lake in 2017 due to unusually high water levels and fire area closures. This area was visited in 2018 and 1,300 invasive plants were treated along the shoreline. Spruce Lake (Figure 9) continues to harbor a persistent invasive plant seedbed. One potential new invasive plant species was encountered at Spruce Lake for the first time this year: a population of *Cardamine* sp. was found growing around the shoreline. At the time of discovery, there were no flowers or fruits present on the specimens and a positive identification could not be determined from the basal rosette of leaves alone. The plant is potentially *C. flexuosa*, and determination will have to be made when the plant can be properly identified.

Poison Meadows continues to be a source of major invasive plant infestations, largely due to the area's disturbance history. This area was added to CRLA in the 1980s; prior to this it experienced livestock grazing and limited timber harvest. Additionally, the area is heavily used by wildlife species and contains large wallow areas and many game trails. In 2018 the Poison Meadows area was visited multiple times throughout the season, with 15,632 invasive plants treated. Most of the meadows are heavily infested with several invasive plant species, and multiple visits are required to control invasive plants throughout the field season.



Figure 9. Water levels at Spruce Lake were lower in 2018 exposing the shoreline and facilitating invasive plant treatment. Photo by Alissa Iverson.

Invasive plant survey for the Thousand Springs region was expanded in 2018 to include a meadow (now Thousand Springs south) located along the Park boundary approximately 1,500 meters south of the main Thousand Spring area (now Thousand Springs north). In the main Thousand Springs meadow, the IVM crew discovered small infestations of St. John's wort (*Hypericum perforatum*) and sheep sorrel (*Rumex acetosella*) that were found among the main dandelion (*Taraxacum officinale*) infestation.

Riparian areas within the Park that have historically been surveyed include Annie, Bybee, Castle, Crater, National, Pothole, Sand, and Sun Creeks. In 2018, Bybee, Sand, Pothole, and lower Sun Creeks were not surveyed due to lack of time.

Annie Creek was surveyed several times in 2018, resulting in 1,092 plants treated with bull thistle and dandelion the most widespread. In 2018, three main sheep sorrel infestation areas were

encountered, demonstrating that sheep sorrel is now established at several locations in Annie Creek. National Creek harbors the Park's largest known infestation of Canada thistle. This infestation was treated with herbicide for the first time in 2017. Canada thistle population size was greatly reduced from 2,738 individuals (2017) to 241 individuals (2018).

A total of 843 invasive plants were treated from Lower Castle Creek and its adjacent sloping meadow with dandelion and bull thistle infestations the largest and most abundant. The north fork of Castle Creek was not treated in 2018 and will need treatment in 2019. The IVM crew treated 775 plants along Crater Creek, with Canada and bull thistles present in the greatest numbers.

Table 2. Number of invasive plants treated in the Backcountry Zone from 2015—2018 by IVM region. Asterisks (*) indicate treatment was missed for a given year.

Backcountry Zone IVM Region	2018	2017	2016	2015
Annie Creek	1,092	4,025	3,718	5,923
Bybee Creek - Lower	*	*	*	44
Bybee Fire	626	699	*	*
Castle Creek - Lower	843	1,655	972	1,373
Castle Creek – North Fork	*	180	261	584
Castle Crest Wildflower Garden	*	12	*	1
Castle Fire	2,102	1,155	1,442	5,189
Cornerstone Burn Unit	*	0	*	*
Crater Creek	775	759	*	3,083
Desert Ridge Fire (NCC)	111	365	*	*
National Creek	241	2,738	2,000	*
National Creek Complex	1,036	2,547	1,084	*
Panhandle - Interior	40	*	205	324
Panhandle - Cottonwood Meadow	2,552	2,255	469	1,591
PH3 Burn Unit	14	1	*	542
Poison Meadows	15,632	17,187	6,362	4,766
Pothole Creek	*	391	46	500
Pumice Complex	3	*	6	0
Red Blanket Canyon	4,852	2,809	8,965	16,448
Sand Creek	*	*	*	386
Spruce Lake	1,300	0	249	2,276
Spruce Lake Fire	3,008	*	*	*
Sun Creek	2,500	8,942	2,702	2,457
Thousand Springs (North & South)	6,076	3,800	3	*
Upper Panhandle Burn Unit/Baboon	5,880	1,519	1,116	16,467
Total	48,683	51,024	29,600	61,411

Table 3. Number of invasive plants treated in the Backcountry Zone from 2015—2018 by plant species. Asterisks (*) denote species that weren't encountered and/or treated in a particular year.

Plant Species	2018	2017	2016	2015
Smooth brome (<i>Bromus inermis</i>)	10	*	*	*
Cheat grass (<i>Bromus tectorum</i>)	*	*	105	161
Canada thistle (<i>Cirsium arvensis</i>)	1,454	4,091	2,942	757
Bull thistle (<i>Cirsium vulgare</i>)	8,396	7,554	13,166	34,899
Field bindweed (<i>Convolvulus arvensis</i>)	*	*	50	900
Tall orchardgrass (<i>Dactylis glomerata</i>)	*	*	1	*
Jerusalem oak (<i>Dysphania botrys</i>)	*	20	*	*
St. John's wort (<i>Hypericum perforatum</i>)	1,836	54	592	701
Hairy cat's ear (<i>Hypochaeris radicata</i>)	127	*	*	4
Dyer's woad (<i>Isatis tinctoria</i>)	*	74	*	*
Tall lettuce (<i>Lactuca canadensis</i>)	*	822	1	591
Prickly lettuce (<i>Lactuca serriola</i>)	671	229	401	1,124
Wall lettuce (<i>Mycelis muralis</i>)	399	*	*	*
Reed canarygrass (<i>Phalaris arundinacea</i>)	1,374	1,090	865	300
Timothy (<i>Phleum pratense</i>)	2,702	2,580	16	50
Annual bluegrass (<i>Poa annua</i>)	*	10	94	*
Bulbous bluegrass (<i>Poa bulbosa</i>)	*	*	*	55
Sheep sorrel (<i>Rumex acetosella</i>)	4,257	8,999	2,820	*
Curly dock (<i>Rumex crispus</i>)	*	*	*	72
Tansy ragwort (<i>Senecio jacobaea</i>)	421	10	9	*
Woodland groundsel (<i>Senecio sylvaticus</i>)	4,267	43	304	7,331
Common groundsel (<i>Senecio vulgaris</i>)	50	*	*	*
Prickly sow thistle (<i>Sonchus asper</i>)	185	1	*	39
Red sandspurry (<i>Spergularia rubra</i>)	200	*	*	*
Dandelion (<i>Taraxacum officinale</i>)	12,274	17,565	3,323	3,779
Yellow salsify (<i>Tragopogon dubius</i>)	8,337	7,558	4,311	5,274
White clover (<i>Trifolium repens</i>)	85	235	112	*
Mullein (<i>Verbascum thapsus</i>)	1,638	89	387	5,366

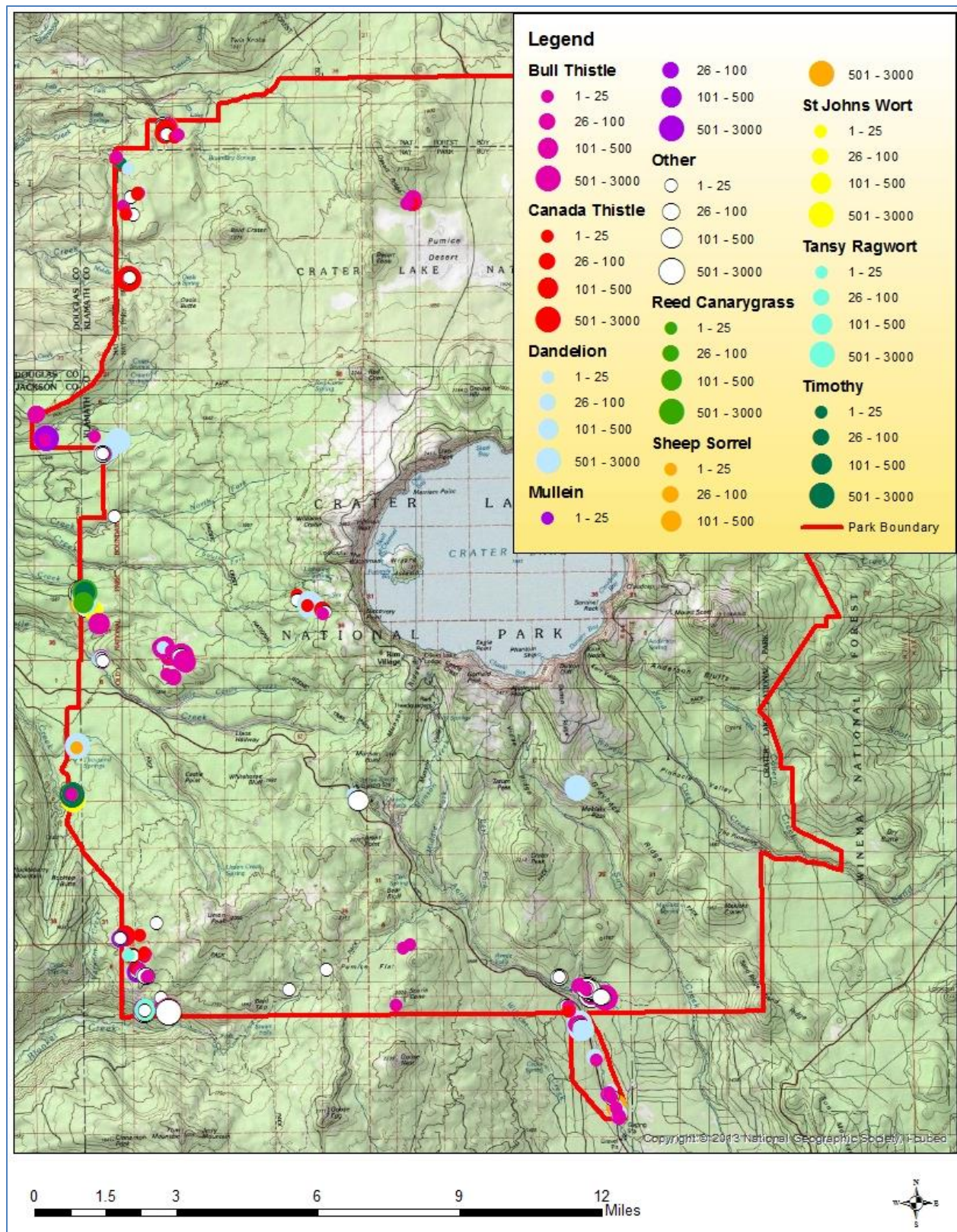


Figure 10. 2018 invasive plant populations in the Backcountry Zone. Map by Jen Hooke.

Developed Zone

The Park's developed areas are Rim Village, Park headquarters/housing, Mazama Dorms, Mazama Village and Cabins, Mazama Campground, the Park's two sewage lagoons, water storage areas, and the Lost Creek Campground. All areas receive high levels of foot and vehicle traffic and routine maintenance, which are potential vectors for establishment of invasive vegetation. In 2018, 18,677 invasive plants were controlled in the Park's developed areas (Figure 11). Comparisons with findings from the 2015—2017 field seasons are made in Tables 4 and 5.

Across all developed areas, sheep sorrel and red sandspurry were the most commonly encountered invasive plant species, though there was also a large increase in the amount of pineapple weed (*Matricaria discoidea*) treated. Of the 13 other species found, only broadleaf cottonrose (*Filago pyramidata* var. *pyramidata*), dandelion (*Taraxacum officinale*), Canada bluegrass (*Poa compressa*), and common knotweed (*Polygonum aviculare* ssp. *depressum*) had infestations of more than 200 individuals. Two species new to developed areas were discovered and treated in 2018: meadow foxtail (*Alopecurus pratensis*) at Mazama Village and big chickweed (*Cerastium fontanum* ssp. *vulgare*) at Rim Village.

The overwhelming majority of invasive plants in the Park's developed areas were found at Rim Village, with Park headquarters/housing containing significant infestations as well. The 2018 field season saw a nearly 66 percent drop in the total number of invasive plants treated compared to 2017. The decline in treatment numbers can be attributed almost exclusively to smaller sheep sorrel and red sandspurry populations. It should be noted that red sandspurry is not a high priority weed for treatment Park-wide due to its abundance, but its infestation of restoration areas inhibits the recovery of native plant species so it is treated when time allows in these areas.

Table 4. Number of invasive plants treated in the Developed Zone from 2015—2018 by IVM region. Asterisks (*) indicate treatment was missed for a given year.

Developed Zone IVM Region	2018	2017	2016	2015
Headquarters/Housing	3,797	8,520	18,815	16,181
Lost Creek Campground	0	0	45	7
Mazama Campground	118	0	56	*
Mazama Dorms	3	1,048	4	*
Mazama Village	51	594	2,926	36
Rim Village	14,708	46,052	27,496	30,630
Total	18,677	56,214	49,342	46,854

Table 5. Number of invasive plants treated in the Developed Zone from 2015—2018 by plant species. Asterisks (*) denote species that weren't encountered and/or treated in a particular year.

Plant Species	2018	2017	2016	2015
Meadow Foxtail (<i>Alopecurus pratensis</i>)	30	*	*	*
Yellow rocket (<i>Barbarea vulgaris</i>)	175	675	554	456
Smooth brome (<i>Bromus inermis</i>)	*	30	2,628	*
Big Chickweed (<i>Cerastium fontanum</i> ssp. <i>vulgare</i>)	1	*	*	*
Canada thistle (<i>Cirsium arvensis</i>)	*	10	*	*
Bull thistle (<i>Cirsium vulgare</i>)	*	1	2	*
Tall orchardgrass (<i>Dactylis glomerata</i>)	1	12	*	*
Broadleaf cottonrose (<i>Filago pyramidata</i> var. <i>pyramidata</i>)	500	1,025	135	500
St. John's wort (<i>Hypericum perforatum</i>)	9	11	125	16
Field pepperweed (<i>Lepidium campestre</i>)	*	*	*	15
Birdsfoot trefoil (<i>Lotus corniculatus</i>)	*	1	*	2
Pineapple weed (<i>Matricaria discoidea</i>)	1,615	729	635	73
Yellow sweet clover (<i>Melilotus officinalis</i>)	*	1	*	*
English plantain (<i>Plantago lanceolata</i>)	1	3	*	*
Common plantain (<i>Plantago major</i>)	2	27	5	87
Annual bluegrass (<i>Poa annua</i>)	*	140	7	*
Bulbous bluegrass (<i>Poa bulbosa</i>)	*	1	*	*
Canada bluegrass (<i>Poa compressa</i>)	250	*	*	350
Common knotweed (<i>Polygonum aviculare</i> ssp. <i>depressum</i>)	305	1,019	*	*
Sheep sorrel (<i>Rumex acetosella</i>)	7,288	26,528	15,846	5,408
Curly dock (<i>Rumex crispus</i>)	*	25	*	6
Red sandspurry (<i>Spergularia rubra</i>)	8,103	24,717	25,046	38,542
Dandelion (<i>Taraxacum officinale</i>)	294	713	2,857	834
Yellow salsify (<i>Tragopogon dubius</i>)	1	*	*	5
White clover (<i>Trifolium repens</i>)	102	545	1,333	533
Mullein (<i>Verbascum thapsus</i>)	*	1	2	2

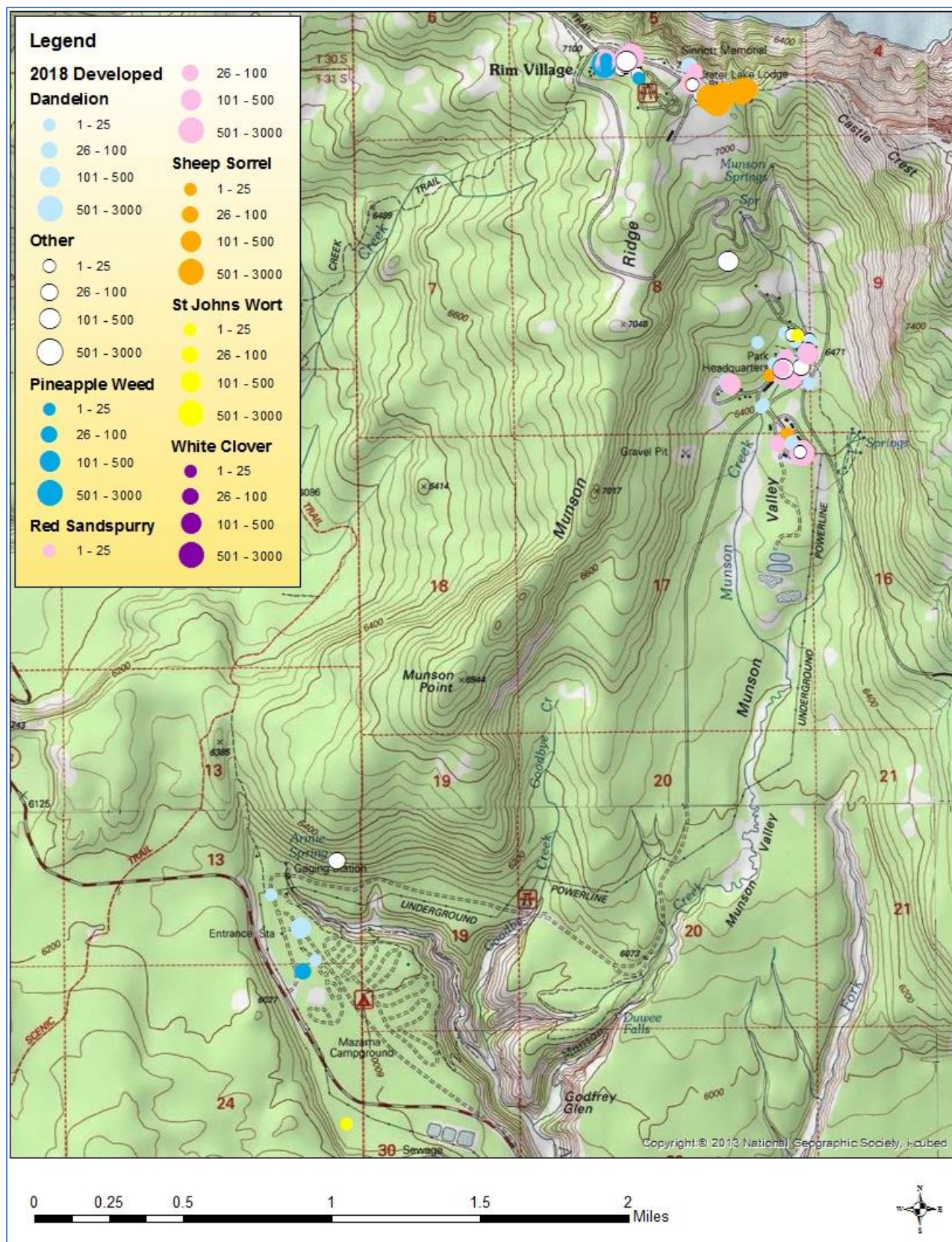


Figure 11. 2018 invasive plant populations in the Developed Zone. Map by Jen Hooke.

Lakeshore Zone

The shore of Crater Lake contains several invasive plant species; the most difficult to control are Canada thistle, St. John's wort, and sheep sorrel. These three species are perennial and rhizomatous; in sandy soils it has been possible to extract the entire root mass of some plants, and a reduction in population size has been achieved in past years. In other areas with rocky or harder substrates, manual treatment methods have been less effective as plants can sprout from tiny root fragments left behind in the soil. In 2017, invasive plant populations were treated with herbicide for the first time, which may be a more effective method than manual removal in rocky areas. Invasive plant populations encountered along the lakeshore are displayed in Figure 13. Comparisons with findings from the 2015 to 2017 field seasons are made in Tables 6 and 7.

The IVM Crew was able to survey the lakeshore (Figure 12) during one week in 2018 from July 23rd to July 26th. The Park's Lake crew was able to transport the IVM crew to locations around the lakeshore via boat to survey, targeting previously known invasive plant infestations. These areas include the Watchman Bench, Palisade Point to Grotto Cove, Skell Head, Chaski Bay, and Wizard Island (boat docks, trails, and shoreline). Grotto Cove and Skell Head were not as thoroughly surveyed as they were in 2017.



Figure 12. Surveying for invasive plants along the Crater Lake shore. Photos by J.C. McNelly.

A total of 579 invasive plants were treated on the lakeshore this year, compared to 253 in 2017. The hotspots for invasive plant infestations continue to be the Watchman Bench and Wineglass areas. Steel Bay was not surveyed this season, although there have been invasive plant species treated there in previous years. Other areas with recorded infestations, such as Chaski Bay and near Phantom Ship, appeared to be relatively clear of invasive plant species.

A dramatic decrease in Canada thistle occurrence around the lakeshore was experienced this field season with only two plants encountered. In 2007, over 750 Canada thistle plants were found along the lakeshore. An increase in the size of St. John's wort populations was encountered in 2018 as

well, primarily along the Watchman Bench. These infestations emerged in 2017; previously St. John's wort along the Lakeshore had been confined to the Wineglass area. Approximately 115 St. John's wort plants were found in the Wineglass area, and these were relatively small in size. The seed bank in this area is gradually being depleted with annual control efforts. The sheep sorrel population below Rim Village emerged again this year after being undetectable in 2017.

Table 6. Number of invasive plants treated in the Lakeshore Zone from 2015—2018 by IVM region. Asterisks (*) indicate treatment was missed for a given year.

Lakeshore Zone IVM Region	2018	2017	2016	2015
Cleetwood Cove to Skell Head	117	225	127	147
Skell Head to Eagle Point	0	*	0	*
Eagle Point to Discovery Point	0	0	338	*
Discovery Point to Merriam Point	469	15	203	173
Merriam Point to Cleetwood Cove	*	*	*	*
Wizard Island	0	13	5	122
Total	586	253	606	442

Table 7. Number of invasive plants treated in the Lakeshore Zone from 2015—2018 by plant species. Asterisks (*) denote species that weren't encountered and/or treated in a particular year.

Plant Species	2018	2017	2016	2015
Canada thistle (<i>Cirsium arvensis</i>)	2	30	126	99
Bull thistle (<i>Cirsium vulgare</i>)	*	1	13	5
Jerusalem oak (<i>Dysphania botrys</i>)	*	2	*	*
St. John's wort (<i>Hypericum perforatum</i>)	408	210	31	110
Hairy cat's ear (<i>Hypochaeris radicata</i>)	*	*	9	9
Prickly lettuce (<i>Lactuca serriola</i>)	*	*	20	*
Kentucky bluegrass (<i>Poa pratensis</i>)	16	*	*	*
Sheep sorrel (<i>Rumex acetosella</i>)	144	*	300	*
Woodland groundsel (<i>Senecio sylvaticus</i>)	*	*	*	122
Dandelion (<i>Taraxacum officinale</i>)	16	7	77	19
Yellow salsify (<i>Tragopogon dubius</i>)	*	3	30	*
Mullein (<i>Verbascum thapsus</i>)	*	*	0	78

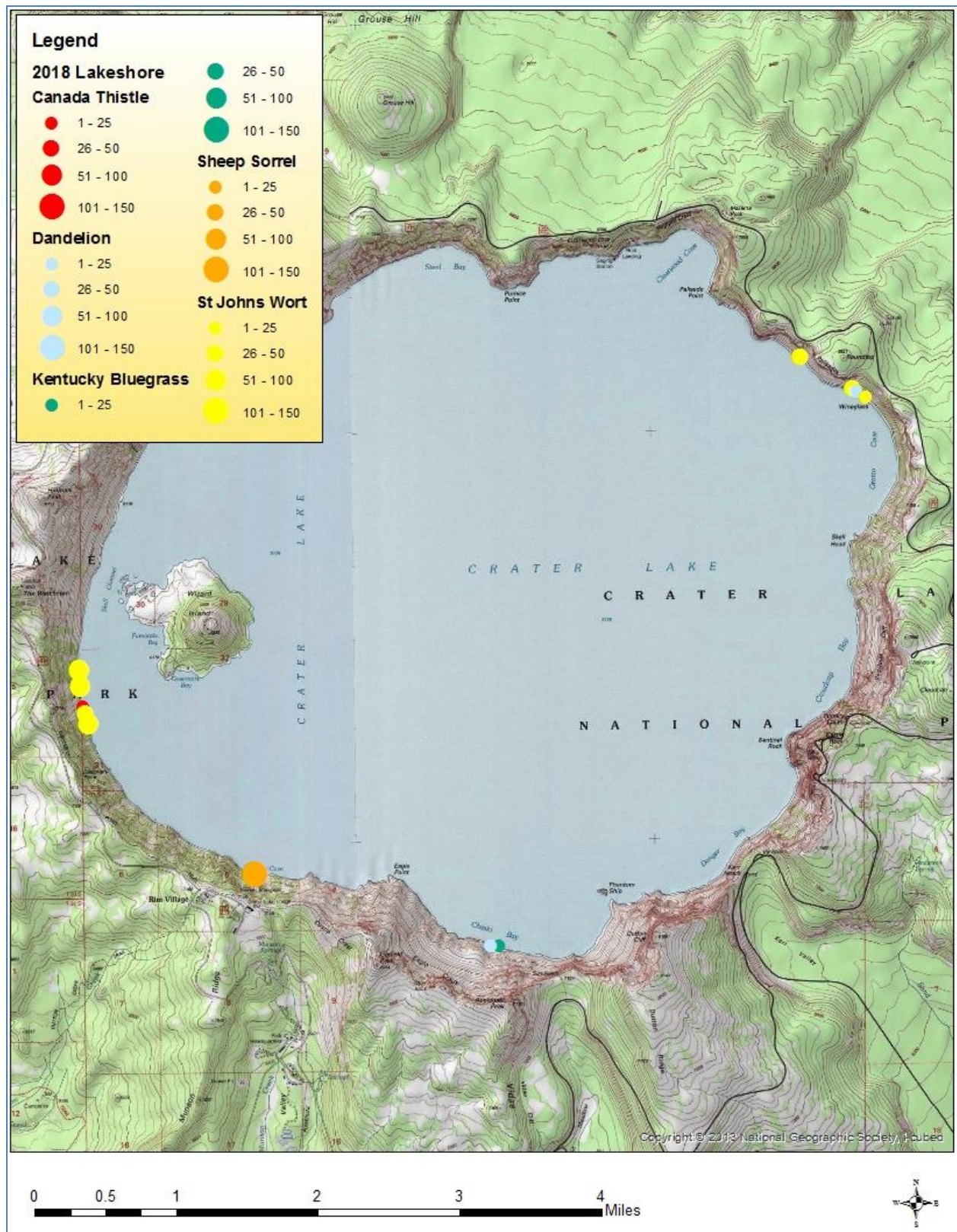


Figure 14. 2018 invasive plant populations in the Lakeshore Zone. Map by Jen Hooke.

Roadside Zone

Park roads include Highway 62, Munson Valley Road, West and East Rim Drives, Pinnacles Road, Grayback Road (closed to public motor vehicle traffic), North Entrance Road, and Highway 138. Of these, only Grayback Road has been found to be free of invasive plant species. The greatest concentrations of invasive plants in the Park are found along roadsides, as roads serve as conduits for invasive plant introduction and their constant maintenance creates ground disturbance that exacerbates their establishment and spread. In 2018, all roads within the Park were surveyed for invasive species with the exceptions of North Entrance Road and Pinnacles Road. West Rim Drive was very lightly surveyed this season due to road construction. Highway 62 and Munson Valley Road were early season priorities (Figure 15), but backcountry areas were a greater focus for the rest of the season. Thirty two invasive plant species were found along CRLA roadsides including a new species to the Park: common tansy. Roadside invasive plant locations encountered in 2018 are displayed in Figure 16. Comparisons with findings from the 2015—2018 field season are made in Tables 8 and 9.



Figure 15. Left: Treating invasive plants along East Rim Drive (photo by Carrie Wyler). Right: Treating invasive plants along south Highway 62 (photo by Melody Frederic).

Highway 62 contains the largest and most abundant infestations of invasive plant species with Highway 138 and Munson Valley Road also supporting considerable infestations. West and East Rim Drives contain localized infestations of invasive plant species; portions of these roads have been found to be weed-free. North Entrance Road is typically sparsely colonized by invasive plants; very few infestations have been found along this road in the past and most have been associated with the North Entrance Station infrastructure and the junction with Highway 138. An invasive plant problem area that emerged along the North Entrance Road in 2015 is the Pumice Desert overlook. This site has supported invasive plant infestations annually since it was used to stockpile gravel “chips” for a

pavement preservation project in 2014. This year it continued to harbor field bindweed (*Convolvulus arvensis*) and purple anther field pepperweed (*Lepidium heterophyllum*), and a new infestation of colonial bentgrass (*Agrostis capillaris*) emerged here in 2018.

Spotted knapweed populations continued their decline in 2018 after many years of regular treatment. Only 12 plants were treated this year, down from a peak of 1,002 plants in 2004. The perennial grass meadow foxtail (*Alopecurus pratensis*) was treated for the first time since 2015 with a wide distribution along most of Highway 138 and Highway 62. This invasive plant species was probably overlooked in 2016 and 2017. Bulbous bluegrass (*Poa bulbosa*) was encountered less frequently than in 2017 but remained abundant along south Highway 62 especially in the Panhandle. Cheat grass was found to be more abundant than in 2017, but population sizes were smaller than in 2015 and 2016. The use of herbicide on invasive plant infestations since 2017 was an important step forward in effectively treating plant species that do not respond well to manual treatments. This could be responsible for declining populations of sheep sorrel, smooth brome (*Bromus inermis*), and St. John's wort.

At its peak in 2006, St. John's wort was enumerated at over 18,000 plants. In 2018, roadside St. John's wort was down to 298 individuals, which is the smallest infestation size reported since invasive plant records began in 1998. The 2005 annual report (Coleman 2005) for the Invasive Vegetation Management program described the St. John's wort infestation along Highway 62 within the Park as follows, *"This population begins at the [southern] boundary and extends past Lodgepole picnic area. Although this population of Hypericum perforatum generally becomes more sporadic and less abundant as it moves up Highway 62 S., it continues to expand at an alarming rate."* Another drastic decline in invasive plant infestation size was encountered this season for Jerusalem oak (*Dysphania botrys*), which is believed to have been introduced to the Park through contaminated gravel used on a 2014 pavement preservation project. After four consecutive years of treatment, no Jerusalem oak individuals were detected in 2018.

Table 8. Number of invasive plants treated in the Roadside Zone from 2015—2018 by IVM region. Asterisks (*) indicate treatment was missed for a given year.

Roadside Zone IVM Region	2018	2017	2016	2015
East Rim Drive	170	5,665	790	287
Highway 138	4,260	9,373	8,281	3,727
Munson Valley Road	3,547	4,649	3,692	25,897
North Entrance Road	*	160	126	337
Pinnacles Road	*	56	30	*
South Highway 62	11,723	24,212	12,441	12,847
West Highway 62	1,042	9,530	2,692	3,805
West Rim Drive	1	*	1,653	1,827
Total	20,967	53,645	29,705	48,727

Table 9. Number of invasive plants treated in the Roadside Zone from 2015—2018 by plant species. Asterisks (*) denote species that weren't encountered and/or treated in a particular year.

Plant Species	2018	2017	2016	2015
Colonial bentgrass (<i>Agrostis capillaris</i>)	10	*	*	*
Redtop (<i>Agrostis gigantea</i>)	15	31	*	*
Meadow foxtail (<i>Alopecurus pratensis</i>)	83	*	*	8
Tall oatgrass (<i>Arrhenatherum elatius</i> var. <i>elatius</i>)	1	5	1	*
Yellow rocket (<i>Barbarea vulgaris</i>)	2	48	*	1
Field mustard (<i>Brassica rapa</i>)	1	*	*	2
Soft chess (<i>Bromus hordeaceus</i>)	*	*	1,659	129
Smooth brome (<i>Bromus inermis</i>)	731	11,235	2,186	2,537
Cheat grass (<i>Bromus tectorum</i>)	301	71	1,933	2,217
Shepherd's purse (<i>Capsella bursa-pastoris</i>)	*	*	*	1
Spotted knapweed (<i>Centaurea stoebe</i> ssp. <i>micranthos</i>)	12	33	58	517
Big chickweed (<i>Cerastium fontanum</i> ssp. <i>vulgare</i>)	*	*	*	47
Lambs quarters (<i>Chenopodium album</i>)	3	*	*	1,063
Rush skeletonweed (<i>Chondrilla juncea</i>)	2	5	3	3
Chicory (<i>Cichorium intybus</i>)	*	1	*	1
Canada thistle (<i>Cirsium arvensis</i>)	1	2	*	8
Bull thistle (<i>Cirsium vulgare</i>)	*	3	33	8
Field bindweed (<i>Convolvulus arvensis</i>)	9	15	20	17
Wild carrot (<i>Daucus carota</i>)	*	1	*	*
Tall orchardgrass (<i>Dactylis glomerata</i>)	*	*	30	20
Flixweed (<i>Descurainia sophia</i>)	*	*	1	*
Jerusalem oak (<i>Dysphania botrys</i>)	*	94	1,110	21,454
Quackgrass (<i>Elymus repens</i>)	*	*	425	186
African filaree (<i>Erodium cicutarium</i>)	*	*	*	1
Ivy bindweed (<i>Fallopia convolvulus</i>)	*	*	*	231
Common velvetgrass (<i>Holcus lanatus</i>)	*	*	14	*
St. John's wort (<i>Hypericum perforatum</i>)	298	1,572	1,715	4,668
Hairy cat's ear (<i>Hypochaeris radicata</i>)	1	9	10	3
Dyer's woad (<i>Isatis tinctoria</i>)	*	31	*	*
Tall lettuce (<i>Lactuca canadensis</i>)	*	*	4	1
Prickly lettuce (<i>Lactuca serriola</i>)	*	*	*	35
Field pepperweed (<i>Lepidium campestre</i>)	16	*	*	28
Purple anther field pepperweed (<i>Lepidium heterophyllum</i>)	197	410	24	12
Oxeye daisy (<i>Leucanthemum vulgare</i>)	7	10	60	79
Perennial ryegrass (<i>Lolium perenne</i>)	*	*	*	8

Plant Species	2018	2017	2016	2015
Birdsfoot trefoil (<i>Lotus corniculatus</i>)	*	*	*	1
Pineapple weed (<i>Matricaria discoidea</i>)	*	60	1	1
White sweet clover (<i>Melilotus albus</i>)	*	*	1	2
Reed canarygrass (<i>Phalaris arundinacea</i>)	12	*	*	20
Timothy (<i>Phleum pratense</i>)	15	102	*	78
English plantain (<i>Plantago lanceolata</i>)	3	*	5	981
Common plantain (<i>Plantago major</i>)	1	31	5	115
Annual bluegrass (<i>Poa annua</i>)	*	40	115	*
Bulbous bluegrass (<i>Poa bulbosa</i>)	6,423	9,251	2,340	3,900
Canada bluegrass (<i>Poa compressa</i>)	267	*	47	*
Kentucky bluegrass (<i>Poa pratensis</i>)	1,788	18	*	*
Common knotweed (<i>Polygonum aviculare</i> ssp. <i>depressum</i>)	*	296	30	1,168
Dog rose (<i>Rosa canina</i>)	*	*	1	*
Sheep sorrel (<i>Rumex acetosella</i>)	6,954	23,779	13,608	4,317
Russian thistle (<i>Salsola kali</i> ssp. <i>pontica</i>)	*	*	*	5
Tansy ragwort (<i>Senecio jacobaea</i>)	*	67	*	*
Woodland groundsel (<i>Senecio sylvaticus</i>)	5	*	1	1
Red sandspurry (<i>Spergularia rubra</i>)	28	*	1,799	1,404
Common tansy (<i>Tanacetum vulgare</i>)	1	*	*	*
Dandelion (<i>Taraxacum officinale</i>)	3,358	4,695	2,137	3,135
Pubescent wheatgrass (<i>Thinopyrum intermedium</i>)	75	*	*	36
Yellow salsify (<i>Tragopogon dubius</i>)	99	50	69	165
Scentless mayweed (<i>Tripleurospermum inodorum</i>)	*	*	1	1
Red clover (<i>Trifolium pratense</i>)	*	1	1	1
White clover (<i>Trifolium repens</i>)	30	1,642	188	6
Wheat (<i>Triticum aestivum</i>)	*	*	*	9
Mullein (<i>Verbascum thapsus</i>)	3	37	19	96

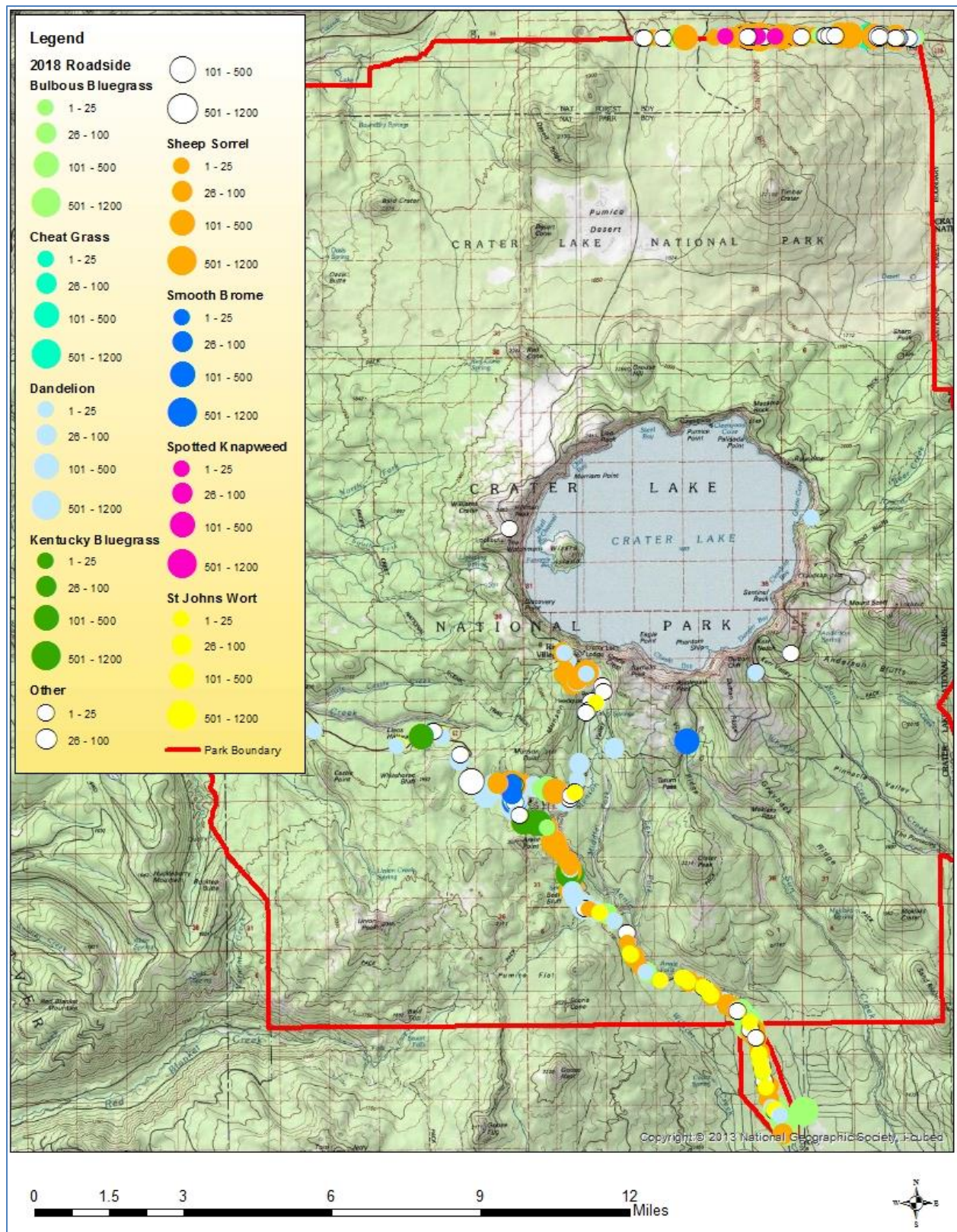


Figure 16. 2018 invasive plant populations in the Roadside Zone. Map by Jen Hooke.

Staging Areas Zone

Crater Lake National Park has six staging areas. These include four historic quarries (Pole Bridge Creek Quarry, Watchman Quarry, Anderson Quarry, and Roundtop Quarry) and two maintenance yards (South Yard and the Ball Diamond) that are used for staging and storage of materials, vehicles, and equipment. These staging areas are often locations where piles of earthen base materials are stored for road construction projects; where rock is stored and worked for masonry projects; where hazard trees and chipped materials from vegetation clearing are stored and processed; and where various Park materials and supplies are stockpiled and stored for various amounts of time. The staging areas often have heavy equipment working to move and process large piles of materials. Due to the active nature of these places, and to the fact that materials stored here can originate from outside the Park and move freely throughout the Park, it is vital that the IVM program keeps these areas as free of invasive plant species as possible. Staging area invasive plant locations encountered in 2018 are displayed in Figure 18. Comparisons with findings from the 2015 to 2018 field seasons are made in Tables 10 and 11.

A total of 61 invasive plants were encountered throughout the Park's staging areas in 2018. Yellow rocket was the most common invasive plant species encountered in these areas. The Park's staging areas continued to be actively used in 2018. Watchman quarry receives the lightest use with materials being moved around and transported by primarily the Trails program. Pole Bridge Creek quarry (Figure 17), South Yard, and the Ball Diamond receive the heaviest use, with routine use of heavy equipment and large amounts of materials being moved around, staged, and stockpiled.



Figure 17. Materials stored for later use at the Pole Bridge Creek Quarry. Photo by Jen Hooke.

Large reductions in invasive plant occurrences have been experienced in the Park’s staging areas over the past decade. In 2010, yellow rocket (*Barbarea vulgaris*) infestations at Anderson quarry and Pole Bridge Creek quarry were 1,010 and 435 individuals, respectively. In 2018, 38 yellow rocket plants were found at Anderson quarry with 9 plants found at Pole Bridge Creek quarry. In 2006, 1,500 mullein (*Verbascum thapsus*) plants were treated at the South Yard; whereas two mullein plants were treated there in 2018.

Table 10. Number of invasive plants treated in the Staging Area Zone from 2015—2018 by IVM region. Asterisks (*) indicate treatment was missed for a given year.

Staging Area	2018	2017	2016	2015
Anderson Quarry	47	1	73	25
Ball Diamond	0	1,420	*	*
Pole Bridge Creek Quarry	9	31	239	780
Roundtop Quarry	0	0	0	0
South Yard	5	74	16	1,255
Watchman Quarry	0	0	0	0
Total	61	1,526	328	2,060

Table 11. Number of invasive plants treated in the Staging Area Zone from 2015—2018 by plant species. Asterisks (*) denote species that weren’t encountered and/or treated in a particular year.

Plant Species	2018	2017	2016	2015
Burdock (<i>Arctium minor</i>)	*	*	*	1
Yellow rocket (<i>Barbarea vulgaris</i>)	9	11	300	700
Smooth brome (<i>Bromus inermis</i>)	*	5	*	*
Bull thistle (<i>Cirsium vulgare</i>)	1	4	*	*
Stinking pepperweed (<i>Lepidium ruderales</i>)	*	*	*	12
Bulbous bluegrass (<i>Poa bulbosa</i>)	*	1	*	*
St. John’s wort (<i>Hypericum perforatum</i>)	*	*	5	6
Red sandspurry (<i>Spergularia rubra</i>)	*	1,432	6	88
Dandelion (<i>Taraxacum officinale</i>)	*	9	4	1
Yellow salsify (<i>Tragopogon dubius</i>)	2	31	*	*
Mullein (<i>Verbascum thapsus</i>)	2	33	13	10

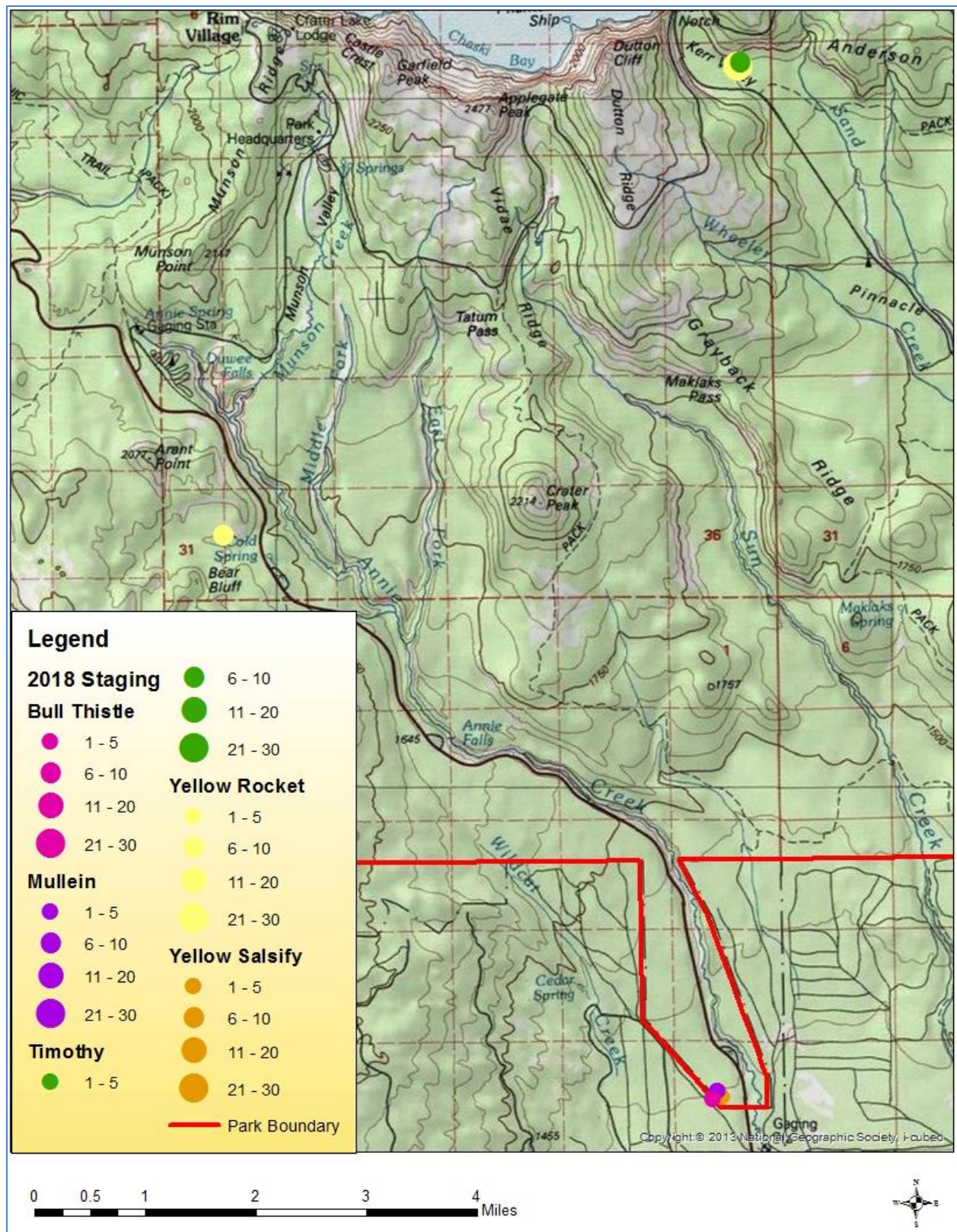


Figure 18. 2018 invasive plant populations in the Staging Areas Zone. Map by Jen Hooke.

Discussion

The 2018 field season brought many challenges and opportunities to the IVM program. Hiring and funding issues led to a smaller field crew than planned, and one crew member became assigned to light duty during the last month of work due to an injury. Implementation of the new Invasive Vegetation Management Plan allowed for more effective control of invasive plant species in some areas of the Park. The early snowmelt allowed field work to begin a month earlier than 2017, but it also extended the growing season for invasive plant species. While the wildland fires of 2018 produced smoke that reduced air quality, the Park's Timber Crater fires were confined to the extreme northeastern corner of the Park and fire closure areas did not drastically affect IVM field work. The fortunate absence of fires in the western half of the park (Figure 19) allowed for IVM survey and treatment in the 2015 National Creek Complex, 2016 Bybee Creek fire, and the 2017 Blanket Creek and Spruce Lake fires. The fire area closures in 2016 and 2017 had dramatically impeded IVM work on the west side of the Park. Since funding for post-fire invasive plant survey and treatment is limited to only three years post-fire, this was a huge setback to detecting and controlling invasive plants in these areas. There still remains a need for reliable funding to sustain the IVM program, as each year funding is cobbled together from different, unpredictable sources. Keeping regular, sustained momentum going in managing invasive plant species is imperative to protecting the Park's biodiversity.



Figure 19. IVM crew members hike through a west-side forest en route to a known invasive plant infestation. Photo by J.C. McNelly.

Large construction projects, such as the Rim Drive Rehabilitation and the well/pipeline construction at Annie Spring and the Pacific Crest Trail (PCT) trailhead, continue to cause large amounts of ground disturbance, the import of potentially contaminated earthen materials, and increased traffic from heavy equipment and contractor vehicles. Phase I of the Rim Drive Rehabilitation project has been completed, with planning for Phase II commencing in 2019. Phase II of the Rim Drive Rehabilitation project will impact portions of East Rim Drive starting at the Cleetwood Cove parking lot and heading

clockwise towards Park headquarters (the end point for Phase II has not yet been defined). In 2018, the Roads crew performed rockfall mitigation and rock scaling work along East Rim Drive from the southern Cloudcap junction to Park headquarters. This area will need careful invasive plant survey in 2019 due to the increased ground disturbance. Fire Management has completed fuelbreak creation and pile burning along west Highway 62 and the North Entrance Road, again creating ground

disturbance that should be surveyed for invasive plants in 2019. Annual visitation to CRLA in 2018 (694,710 visitors) declined slightly from 2017 numbers (711,749 visitors) but it is still on the high side as the Park usually receives ~500,000 visitors annually. The increase in visitation can contribute to an increase in invasive plant introductions as humans and vehicles are major vectors of invasive plant spread.

The invasive plant treatment data from developed areas underscores the need for continuing collaboration with the Park's Revegetation crew. The Revegetation crew is tasked with invasive plant survey and control work in and around revegetation work areas including Rim Village and Rim Drive, and the PCT well/pipeline construction area. As part of the Rim Drive Rehabilitation project, Roundtop quarry (Figure 20) experienced significant ground and slope disturbance in 2018 in an attempt to restore the area back to pre-construction conditions. Roundtop quarry had slash piles removed and slope recontouring which left a large area of exposed soil. The Mazama Dorms area also experienced ground disturbance resulting from roof replacement. All of these areas will be need meticulous invasive plant survey in 2019, and data and findings shared between the IVM and Revegetation crews.

The 2018 season experienced a heightened degree of disturbance arising from visitors driving off-pavement. The worst of this was experienced in the Pumice Desert as a visitor made over three miles of vehicle tracks including many "donuts" that displaced soils to over a foot in depth and killed all vegetation in these areas (Figure 20). The Pumice Desert damage was mapped and this area will need follow-up invasive plant survey. The impacted area includes the Pumice Desert Research Natural Area and the Park's recommended wilderness. Other vehicle tracks were focused around Rim Drive, with extensive damage occurring at Grotto Cove, the Cloudcap junction, and the Bear Creek drainage.



Figure 20. Significant disturbance at Roundtop quarry (left) and the Pumice Desert (right) will need to be watched for invasive plant establishment. Photos by Jen Hooke.

Another upcoming project with the potential to cause ground disturbance is rockfall mitigation, trail stabilization, and marina replacement in the Cleetwood Cove area. This area is currently free of invasive plant species, and a large effort should be made to keep it that way.

The Park's Backcountry Zone is one of the most dynamic aspects of invasive vegetation management. In 2018, a new meadow system (Thousand Springs south) was discovered that harbors large invasive plant infestations. The meadows are directly off the U.S. Forest Service Thousand Springs Road. Similar areas should be identified using imagery like Google Earth so that meadows, wet areas, and other open habitats can be surveyed along the entire western border of the Park.

Burned areas continued to be a source of new invasive plant populations, and there will be more burned areas to survey next year due to the Timber Crater 6 Fire (3,121 acres) and Timber Crater 10 Fire (193 acres) in the northeastern corner of the park. Due to the amount of recently burned acres, it is important to focus on areas that are more susceptible to new infestations. These include areas that experienced direct fire suppression impacts (handlines, spike camps, helispots, and areas affected by aerial retardant drops); areas with prior fire history; and areas that burned with moderate to high severity. Other areas to survey include riparian areas, dry creek beds, and areas with low canopy cover. The Timber Crater fires pose a unique problem due to the Timber Crater 6 fire's proximity to Highway 138, which could be a source for invasive plant species, like cheat grass and spotted knapweed, to make their way into the Park. A large amount of fire suppression staging began on or near Highway 138 as well.

The use of herbicide this year greatly increased productivity and time efficiency. It also resulted in less soil disturbance, which is correlated to invasive plant species' spread. The IVM crew was able to spend less time at sites and treat more plants with the use of this treatment method. While ultimately fewer plants were treated this season than in 2017, more areas and greater acreage were surveyed. This reduction in total number of invasive plants treated was caused by either spending more time surveying and less time treating, or the use of herbicide is reducing the size of invasive plant populations from year to year.

Additional recommendations for IVM work in 2019 include:

- When surveying areas burned by the 2018 Timber Crater fires, target portions of the 2007 Cornerstone and 2009 Phoenix prescribed burn units plus the 2014 Founders Day fire that reburned in 2018.
- In 2019, it would be worth surveying the 2004 Bybee and Bybee II fires and the 2006 Bybee fire that are close by the 2008 Castle fire, as invasive plants may have spread to these areas. The easternmost edge of the 2008 Castle fire was not surveyed in 2018, and should be visited in 2019.
- With the high intensity of construction-related soil disturbance experienced on West Rim Drive and since comprehensive invasive plant survey and treatment was not possible there in 2018, multiple surveys are recommended for 2019.
- In the Lakeshore Zone, the IVM crew should focus their efforts on spending one full day walking from the Palisades to Sentinel Rock, another full day on the Watchman Bench, and a full survey made from Eagle to Discovery Points. The remainder of the time on the lake should be spent addressing known infestation areas.
- Frequent and thorough surveys of all meadows in the Poison Meadows area are necessary. This area has large, established, and diverse populations of invasive plant species.

- Focus extra attention on sites that are difficult to survey and harbor large invasive plant infestations including Upper and Lower Red Blanket Canyon and the 2008 Castle Fire areas.
- Make multiple visits to known Canada thistle sites starting in July.
- Take extra time to train people on field data entry individually, and make sure they are well-versed in IVM Regions and carry the IVM Region list with them in the field.
- Go through the protocol for unknown plants with crew members more than once. Ensure unknown plant data forms are complete and the species name is corrected when known.
- Spruce Lake was surveyed in late 2018 and a large concentration of mullein was found. This area is a high priority along with a large thistle population off the road nearby.
- The IVM crew needs to use boot brushes daily and perform daily checks of crew gear for soil and invasive plant seeds.
- Plan backcountry camping trips early in the season to ensure administrative staff can establish travel-related accounts in time. Camping in locations like the Lower Red Blanket Canyon and the northern Spruce Lake fire would greatly increase work productivity.

Serving on an IVM crew is demanding as it requires a high level of arduous physical activity to cover a lot of ground in a short field season, the willingness to use and work with herbicides on a daily basis, and the ability to maintain a positive attitude when work becomes monotonous or field conditions become adverse (e.g., abundant mosquitos and yellow jackets). However, the tangible results of IVM work are rewarding as the crew leaves the Park in much better shape than they found it. In looking at past data, especially from a decade ago, it is obvious that great strides have been made in protecting the Park's native vegetation and overall biodiversity from the changes that invasive plant species can bring to Park ecosystems. Crater Lake National Park would be a much different place if not for the efforts of the IVM crew (Figure 21).

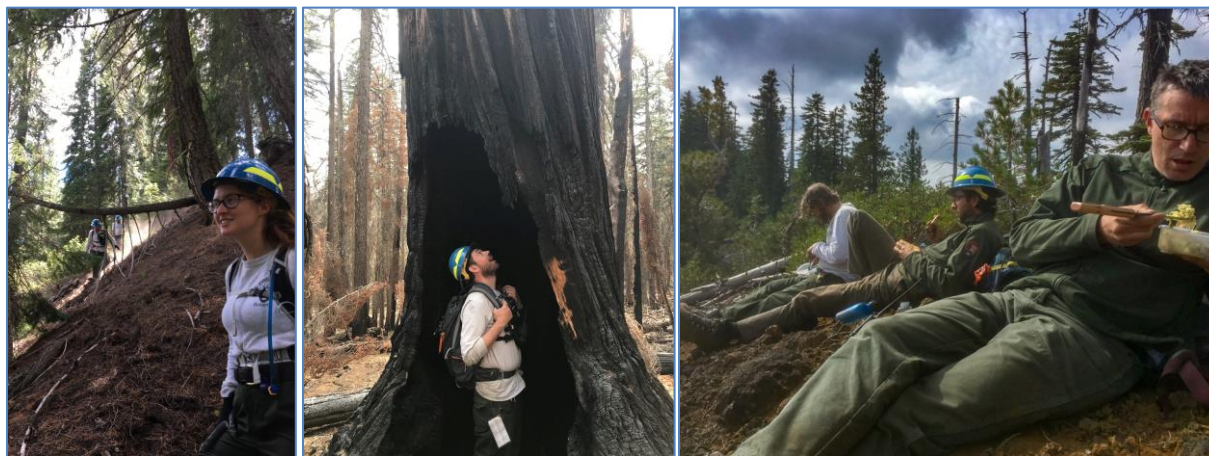


Figure 21. The 2018 IVM crew enjoying life in the field. Photos by Delacey Randall (left), Alissa Iverson (center), and J.C. McNelly (right).

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