National Park Service
U.S. Department of the Interior

Crater Lake National Park

Rim Drive Rehabilitation Revegetation Project

2019 Annual Report

ON THIS PAGE
Planting spreading phlox (*Phlox diffusa*) along West Rim Drive.
Photo by Carrie Wyler

ON THE COVER
Collecting seeds from showy rubber rabbitbrush (*Ericameria nauseosa* var. *speciosa*) along East Rim Drive.
Photo by Carrie Wyler

Rim Drive Rehabilitation Revegetation Project

2019 Annual Report

Carolyn S. Wyler, Scott E. Heisler, Jennifer S. Hooke, Melody C. Frederic, Carson R.T. Ralls, and Benjamin D. Wright

National Park Service
Crater Lake National Park
P.O. Box 7
Crater Lake, Oregon 97604

April 2020

U.S. Department of the Interior
National Park Service
Crater Lake National Park
Crater Lake, Oregon

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.

This report is available in digital format from the Crater Lake National Park website at:

https://irma.nps.gov/DataStore/Reference/Profile/2272680

Please cite this publication as:

Wyler, C.S., S.E. Heisler, J.S. Hooke, M.C. Frederic, C.R.T. Ralls, and B.D. Wright. 2020. Rim Drive Revegetation Project: 2019 Annual Report. Crater Lake National Park, Crater Lake, Oregon.

April 2020

Contents

Figures

Page

Tables

Abstract

Crater Lake National Park's Rim Drive Rehabilitation Revegetation project aims to mitigate impacts to the rim environment from the Federal Highway Administration-sponsored Rim Drive Rehabilitation project. This major construction project is correcting many deficiencies present along the Park's historic Rim Drive and has been split into "Phases" encompassing iterative work progression. Work to date has fallen under Phase I of this project. Through surveying for and controlling invasive plant species, salvaging and reestablishing rare plant populations disturbed by the construction project, and restoring disturbed areas using site-specific native plants and seed it is hoped that long-term impacts from this construction project to the Park's natural resources will be minimized. During the 2019 field season, over 920 invasive plants were removed from the project area. For the seventh year in a row, plant materials were collected from five distinct seed zones representing the floral diversity of the project area. Thirty-four seed accessions were provided to the Corvallis Plant Materials Center by Park staff for cleaning. Site documentation was refined for each disturbed site to inform future restoration efforts and monitor revegetation status of the project. In 2019, Crater Lake National Park staff planted 580 native plants, and dispersed 1,922 grams of native seed throughout disturbed areas along East Rim Drive. On West Rim Drive, 1,125 native plants were outplanted in disturbed areas and 9,565 grams of native seed were broadcast in disturbed areas along the road corridor.

Acknowledgments

The Crater Lake National Park Maintenance staff allowed use of the Ball Diamond at Park headquarters and the South Yard for storage of plant materials and related infrastructure. Planting and seeding assistance were received by members of the Crater Lake National Park Botany staff, especially Delacey Randall, Elena Olsen, Hamilton Hasty, Vance McNees, Sarah Hogan, and Matthew Jelinske. The Meeker Plant Materials Center maintained fields for seed increase efforts. The Corvallis Plant Materials Center aided with seed cleaning and providing plant materials for restoration. The Denver Service Center staff, notably Tracy Cudworth, Ken Stella, and Chris Taliga, provided support with revegetation planning.

Introduction

The Federal Highway Administration (FHWA)-sponsored Rim Drive Rehabilitation (RDR) and Rockfall Mitigation project is a multi-year endeavor to enhance and improve Crater Lake National Park's (CRLA) historic and scenic Rim Drive and its associated pullouts and parking areas. The 29.4-mile-long Rim Drive is a popular Park road and destination; it provides seasonal access to the caldera rim with its many trailheads and scenic vistas of Crater Lake and the surrounding Cascade Range. Rim Drive is listed on the National Register of Historic Places and has been nominated as a cultural landscape. Rim Drive was completed in 1941, and occasional repairs have occurred in the years since its construction. However, major reconstruction is now occurring as existing roadway materials have exceeded their lifespan, and the roadbed and associated masonry features have deteriorated due to erodible soils and years of harsh weather.

Phase I of the Rim Drive Rehabilitation project was initiated in 2014 and focused on rockfall mitigation and road rehabilitation along Rim Drive. In 2014, intensive rockfall mitigation using heavy equipment and rock scaling occurred at Wizard Island Overlook, the Watchman, Sun Grade, Dutton Cliffs, and the Anderson Cut. In 2015 road rehabilitation work commenced that affected six miles of West Rim Drive, portions of East Rim Drive (e.g., North Junction to Cleetwood Cove; Skell Head; Grotto Cove), and the Rim Village parking lot. Major construction work on Phase I was completed in November 2018. Several new (i.e., unplanned) disturbance areas were established in 2016, 2017, and 2018 along West and East Rim Drives resulting from activities such as deep patch work, road realignment, and correcting drainage issues. In addition to impacting roadways and road shoulders, numerous pullouts, parking areas, and parking lots were modified. These modifications included obliterating unofficial pullouts (Figure 1), shrinking the footprint of excessively large parking areas, and installing landscaping islands in high visitor use areas.

Figure 1. User-created pullouts before (left; photo by Carrie Wyler) and after (right; photo by Scott Heisler) obliteration as part of the Rim Drive Rehabilitation project.

Additionally, road work displaced the world's largest known population of the Crater Lake rockcress (*Boechera horizontalis*), a rare plant that is considered a Species of Concern by the United States Fish and Wildlife Service, and a candidate species for listing as threatened or endangered by the state of Oregon.

Due to the substantial impacts occurring to soils and vegetation, FHWA funded efforts to restore affected areas through revegetation, special status plant species management, and invasive vegetation management. The Rim Drive Rehabilitation Revegetation (RDRR) project is tasked with:

1. Developing revegetation prescriptions for disturbed areas to be restored.
2. Surveying for and controlling non-native, invasive plant species within the project area.
3. Salvaging, transplanting, and monitoring special status plants impacted by the project.
4. Collecting native plant seed and materials for revegetation efforts.
5. Restoring affected areas through site preparation, planting, and seeding.
6. Monitoring restored areas for revegetation efficacy and augmenting restoration actions.

Restoration of areas disturbed by the Rim Drive Rehabilitation project (Figure 2) is necessary to jumpstart natural succession of vegetation communities and protect the rim environment from soil erosion and invasion by non-native plant species. Through using site-specific, native genotypes in revegetation efforts, the biodiversity and genetic integrity of the rim vegetation community is maintained.

Figure 2. Conducting restoration outplantings (left) and collecting seed (right) for the Rim Drive Rehabilitation project. Photos by Carrie Wyler.

Additionally, as Rim Drive is a popular Park road, revegetation will yield aesthetic benefits to Park visitors by reducing the appearance of bare, disturbed ground throughout the project area.

Most Phase I construction activities were completed in November 2018; however, work on the Cleetwood Cove parking lot continued into the 2019 field season. All planned pullouts that were originally slated for obliteration along with 25 unplanned disturbance sites along East and West Rim Drives have now been completed and restored. The types of restoration sites along with their restoration status are listed in Table 1. Several elements that were intended to be included in Phase I of the project were not completed. These include Roundtop Quarry restoration, ongoing work at the Cleetwood Cove parking lot, rehabilitation of staging areas, and Watchman Overlook parking islands. These loose ends will be addressed in Phase II of the project, which is slated to begin in spring of 2022. Phase II is presently in the planning stages, but it is believed that this Phase will complete rehabilitation of Rim Drive by working clockwise from Cleetwood Cove to Park headquarters. It is possible, however, that the remaining portion will again be phased, and a Phase III will be needed to complete the project.

Table 1. RDRR restoration areas by location and completion status as of November 2019.

General Location	Type of Site/Location	Number to Restore	Restoration Complete?
West Rim Drive	Obliterated Pullout	14	Yes (14/14)
	Reduced Footprint of Parking Area (Lightning Springs, Last Snow, Glacial Valley)	3	Yes (3/3)
	Rare Plant Population Reestablishment (Watchman)	1	Yes (1/1)
	Unplanned Disturbed Areas	8	Yes (8/8)
	Landscaping Island (Watchman Overlook)	2	No (0/2)**
East Rim Drive	Obliterated Pullout	9	Yes (9/9)
	Roadway Realignment (Pumice Point, Grotto Cove)	2	Yes (2/2)
	Landscaping (Cleetwood Cove Parking Lot and Trailhead)	3	No (2/3)*
	Rare Plant Population Reestablishment (Grotto Cove)	2	Yes (2/2)
	Llao Rock staging area	2	No (0/2)**
	Roundtop Quarry	1	No (0/1)**
	Unplanned Disturbed Areas	17	Yes (17/17)

**Work is ongoing.*

*** These were not completed as per Park standards and will be rolled into Phase II construction.*

As the RDRR project progressed, the overall disturbance footprint became significantly larger than the one planned, necessitating additional time and resources devoted to restoration. Most planned sites ended up larger than what was called for in the original construction plans, and many unplanned sites were disturbed and required restoration.

Five seasonal Biological Science Technicians (Plants) worked on the RDRR project in 2019; season length was from May 13 – October 24. In addition to working in areas directly impacted by the Rim Drive Rehabilitation project, the RDRR program also surveyed areas that were used for staging of project materials and equipment for invasive plant species. Staging areas include two pullouts on East Rim Drive, Roundtop Quarry, the Ball Diamond, and Pole Bridge Creek Quarry.

Methods

Efforts made by the RDRR program in 2019 can be organized into three components: (1) revegetation; (2) special status plant management; and (3) invasive vegetation management; these are described below.

Revegetation

Site Prescriptions

Prior to construction and beginning in 2012, revegetation prescriptions were developed for each area slated for restoration. These prescriptions serve as documentation of the pre-disturbance site features and plant species composition unique to each area. Prescriptions were developed by making visits to each site and recording the dominant plant species with an ocular estimate of each species' relative cover value. This documentation was established with the intent that it would inform revegetation efforts by providing a baseline to determine the number of plants and amount of seed to be used at each site. For most planned sites, photo points were established and photos were taken of each pre-disturbance site. The specifics of this process are outlined in a project-specific Revegetation Plan (Gregory *et al.* 2015).

The previous RDRR crews developed revegetation prescriptions after-the-fact as unanticipated ground disturbance necessitated the addition of new restoration sites. For unplanned disturbance sites, the pre-disturbance vegetation community was destroyed and unavailable for use as a reference; hence, revegetation prescriptions were developed from adjacent undisturbed areas. Revegetation prescriptions can be found in Botany program files at Park headquarters (R:\BOTANY\Ecological Restoration\Rim Drive Rehabilitation project\Revegetation\Site documentation).

Seed Collection

The project area was delineated into seed zones, with each zone serving as a distinct area where seeds and propagated plants could be sourced and moved without compromising genetic integrity. In defining seed zones, sites with similar vegetation communities were grouped together - these groupings corresponded to similarities in site location and elevation. Five seed zones (Figure 4) were defined for the current phase of the RDRR project:

- South West Rim Drive (South WRD)
- Central West Rim Drive (Central WRD)
- North West Rim Drive (North WRD)
- Northwest East Rim Drive (NW ERD)
- Northeast East Rim Drive (NE ERD)

Once seed zones were delineated, a discrete revegetation species list for the project was developed. In order to develop a cost-effective agreement and work plan between CRLA and the Corvallis Plant Material Center (PMC), who has responsibility for seed cleaning, storage, and plant propagation for the RDRR project, it was determined that using eight to ten plant species (accessions) per seed zone would be adequate for revegetation efforts. The Corvallis PMC and Denver Service Center (DSC) staffs recommended collecting large quantities of seed from abundantly occurring species, as custom seed mixes can be supplemented with excess seed that can also be available to accommodate unanticipated disturbance areas. Species substitutions and species additions were approved to help fill any gaps in the species accession list. Additional species were collected by CRLA staff during the 2019 season, with the intention that this extra seed would be cleaned by Park staff and returned to sites in that same season. Table 2 lists all species collected during the 2019 field season.

Figure 3. Monitoring plant phenology to track seed maturity. Photo by Scott Heisler.

The seed collection process commenced in 2019 by observing and documenting the phenology of each targeted species at each revegetation site within each seed zone (Figure 3). Notes were taken on plant phenology, seed maturity, and collection techniques; these observations helped refine seed collection protocols for each species (Beck et al. 2017). Maps were developed for all seed collection locations for species in each seed zone; these are stored on the Botany server.

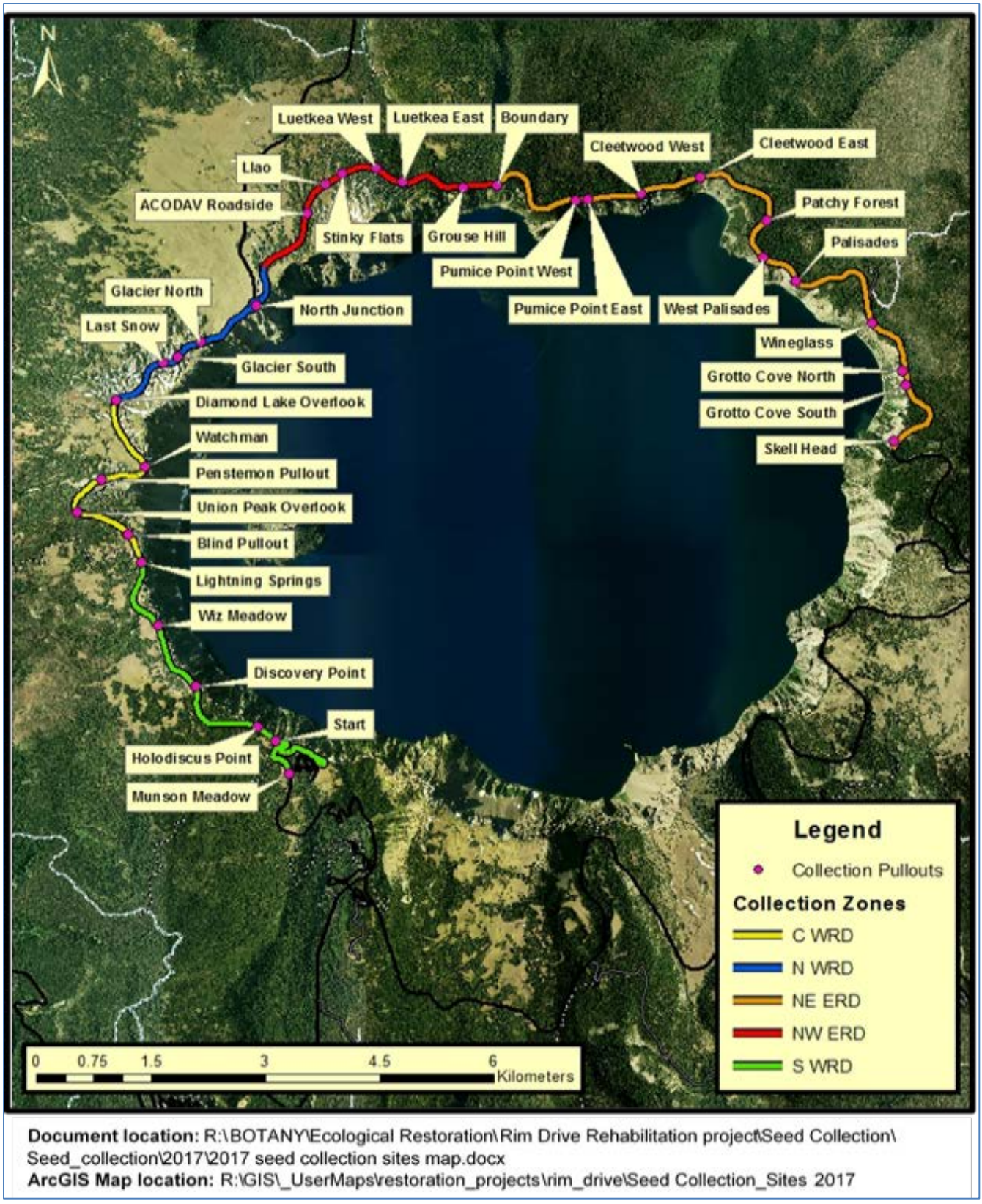


Figure 4. Seed collection zones with notable pullouts indicated. Map by Tara Chizinski.

Table 2. 2019 seed collection list per seed collection zone.

ZONE	PLANT TAXA	
South WRD	*Achnatherum occidentalis*	*Elymus elymoides* ssp. *elymoides*
	Bromus carinatus var. *carinatus*	*Ericameria greenei*
	Calyptridium umbellatum	*Lupinus andersonii*
	Carex halliana	*Lupinus lepidus* var. *lobbii*
	Carex inops	*Phacelia hastata* ssp. *compacta*
	Carex pachycarpa	*Phlox diffusa*
Central WRD	*Achnatherum occidentalis*	*Ericameria greenei*
	Aconogonon davisiae var. *davisiae*	*Eriogonum marifolium* var. *marifolium*
	Calyptridium umbellatum	*Phacelia hastata* ssp. *compacta*
	Castilleja applegatei	*Phlox diffusa*
	Elymus elymoides ssp. *elymoides*	*Polygonum shastense*
North WRD	*Achnatherum occidentalis*	*Elymus elymoides* ssp. *elymoides*
	Aconogonon davisiae var. *davisiae*	*Elymus glaucus ssp. glaucus*
	Bromus carinatus var. *carinatus*	*Lupinus andersonii*
	Calyptridium umbellatum	*Lupinus lepidus* var. *lobbii*
	Carex breweri	*Phlox diffusa*
NW ERD	*Achnatherum occidentalis*	*Juncus parryi*
	Calyptridium umbellatum	*Luetkea pectinata*
	Carex breweri	*Phlox diffusa*
	Elymus elymoides ssp. *elymoides*	
NE ERD	*Achnatherum occidentalis*	*Ericameria nauseosa* var. *speciosa*
	Bromus carinatus var. *carinatus*	*Lupinus andersonii*
	Calyptridium umbellatum	*Lupinus lepidus* var. *lobbii*
	Carex halliana	*Penstemon speciosus*
	Elymus elymoides ssp. *elymoides*	*Phacelia hastata* ssp. *compacta*

When seeds were mature, they were collected, dried, and stored until shipment to the Corvallis PMC. Within each zone a single bag was used to collect all the seed from an individual species (Figure 5). In the field, bags were labelled with species code, collection date, and seed zone. After collection, seeds were transported to the seed drying and storage facility in the Stall Nine garage at Park headquarters (Figure 5). When seeds arrived at this facility, records were kept for each species with collection dates, specific collection location, and seed zone. Seeds were then placed inside 30-gallon plastic storage totes secured with window screen at the top, allowing ventilation while reducing chances of predation. Plant species with very small seeds were first placed in smaller plastic bins before being stored within the larger 30-gallon tubs. The bins were labelled and organized on

shelves by seed zone and species. Damp collections (especially lupines) were either shipped soon after collection (within a week) or set out in the sun during the day to speed the drying process.

Prior to shipping seed to the Corvallis PMC, all seeds from a single species within a discrete seed zone were combined into doubled paper bags; each bag was labeled with species code and seed zone and taped shut. Records were kept of boxes shipped and their contents. Shipping seeds throughout the growing season was crucial due to the shortage of seed storage space at the Park, and inadequate ventilation for effective drying of damp material.

Figure 5. Seed drying and storage facility at Park headquarters (left). Parry's rush seed before cleaning (right). Photos by Carrie Wyler.

Plant Care and Nursery Work

Due to delays in the 2018 construction schedule, planting was not completed that fall and several thousand plants needed to be overwintered at the Ball Diamond nursery at Park headquarters. These plants required care and maintenance throughout the 2019 field season. Once the snow melted in June, plants were covered with a shade house (40'x 20'x10' – Figure 6).

Figure 6. Overwintered plants emerging from the snow in the spring (left). Shadehouse at the Ball Diamond (right). Photos by Carrie Wyler.

The plants were fertilized with Peter's 20-20-20 wetable fertilizer as prescribed by Corvallis PMC staff. Fertilization occurred approximately every 2 weeks at a rate of 1 tsp/gallon. Descriptions of fertilization procedures can be found in Botany program files in the "Nursery Activities" binder. Excess growth was manually trimmed with scissors or hedge clippers as needed. Any reproductive structures were removed to promote root development and prevent excess evapotranspiration, and dead growth was removed to discourage fungal growth. Undesired plant volunteers originating from Corvallis PMC in the planting tubes (e.g., moss, liverworts, and weeds) were removed before planting to minimize the risk of introducing non-native plant species to the Park (Figure 7). Any excessively root bound plants, including many grasses, sedges, spreading phlox (*Phlox diffusa*), and manzanita (*Arctostaphylos* sp.), were transplanted into larger containers or divided. The full details of which plants were transplanted can be found in the "Nursery Activities" Binder at Park headquarters.

Figure 7. Conducting plant care in the Park's shadehouse. Photo by Carrie Wyler.

Despite a successful planting season, many plants are being held over the 2019-20 winter at the Ball Diamond to fill in gaps as needed during the 2020 season. When ambient temperature dropped below freezing the containers were consolidated and mulch was stacked around the bases of herbaceous plants to prevent root freezing (Figure 8). These plants will need further care in the summer of 2020 including watering, fertilization, and transplanting into larger containers.

Figure 8. Distributing mulch around the edges of pots to insulate against frigid winter temperatures (left). Consolidated plants at the Park's Ball Diamond prior to overwintering (right). Photos by Carrie Wyler.

Site Preparation

Prior to planting or seeding a disturbed site, efforts are made to prepare the site for restoration. This entails ensuring the soil has been sufficiently decompacted, making certain the slope and appearance of the disturbed site blends in with the natural topography and appearance of the area, and smoothing out any vehicle tracks, berms, or other unnatural depressions at the site. Soils are amended with Park-sourced woody debris, compost, forest litter and duff, and/or naturally dehisced herbaceous litter (e.g., tumbled Davis' knotweed – *Aconogonon davisiae* var. *davisiae* – stems that accumulate in roadside ditches) as appropriate. For example, forest debris would not be placed on a site to be restored back to a subalpine meadow; nor would meadow litter be placed on a forested site.

Beginning in 2016, Park-sourced mulch/compost and small coarse woody debris were acquired from Pole Bridge Creek Quarry for use in site preparation. With the aid of a large screen plant, partially composted woody debris was processed and sorted. Materials with particle size of < 5 cm were designated as compost and transported to the South Yard for further maturation and maintenance. Slightly larger materials (5 cm – 15 cm particle size), were retained and stored at the Ball Diamond adjacent to the shade house. Compost was routinely turned using heavy equipment for proper decomposition. The compost was, and will continue to be, used on restoration sites (Figure 9).

Figure 9. Compost being hauled from the Pole Bridge Quarry pile to the South Yard pile for use in restoration projects. Photo by Carrie Wyler.

Compost temperature was monitored over the season and was found to be high enough to indicate active biota degrading the material. The compost was used to provide a source of natural fertilizer and mulch for newly planted seedlings. The compost also helped create local microclimates, retain soil moisture, and provide microfauna to help promote soil development and aid the establishment and growth of the seedlings. Woody materials were used to help stabilize recently disturbed and denuded sites from road construction while also helping create microclimates and seed pockets to further encourage the natural recovery of the areas. Larger woody debris (branches, logs, etc.) was obtained from the surrounding forest at disturbed sites and added to restoration sites as appropriate to assist with erosion control and site amelioration.

Planting and Seeding

A mix of plant species were planted in the disturbance areas in accordance with revegetation prescriptions and availability of plant materials. After planting, compost was added, and plants were

watered (Figure 10). Site-specific seed mixes were prepared and hand-broadcast over planted areas, and over areas with slopes that were too steep to plant. After broadcasting seeds, the sites were scarified with hand rakes and compost was broadcast over the scarified areas (Figure 11).

Figure 10. Watering plants after restoration planting (left). Raking seed in at Skell Head (right). Photos by Carrie Wyler.

At restoration sites, holes were dug to a depth equal to or greater than the length of the planting tubes. Plants were carefully removed from the tubes by pressing on the sides of the tubes or tapping the rim of the tubes while they were inverted over the planting holes. After the plants had been removed, the roots were inspected for any signs of being root bound, having roots growing upward in the tube ("J"-rooting), or root girdling. If any of these were found, the roots were either trimmed or gently teased apart to encourage root growth and plant establishment. The plants were then placed in planting holes to ensure they were upright perpendicular to the pull of gravity (not relative to the local topography). Soil was then pushed back into the planting holes and tamped down gently to remove any air pockets in the soil. Plantings were installed so that the root collars of the plants were just at or slightly below the surface of the soil. Remaining soil or additional soil from the surrounding area was used to create a berm wall around the plants to facilitate water retention and help stabilize and protect plants. One or two handfuls of compost were then placed in the center of the rings around plants (Figure 11). After mulching, the plants were watered at least once. A 200-gallon water tank was mounted in the bed of a truck and used in conjunction with an electric pump to facilitate watering of newly planted plugs (Figure 11).

Figure 11. Upper left: Building a berm for a plant. Upper right: Recently installed plants with compost and soil berms to contain water. Bottom photo: The 200-gallon truck-mounted water tank. Photos by Carrie Wyler.

Site Documentation and Monitoring

The restoration process for each site was documented using monitoring forms and photo points. Sites restored prior to 2019 were monitored by making ocular assessments of the survival of planted

species and the degree of vegetation establishment and recovery. Any additional planting and/or seeding needs for the site were noted. These assessments are completed annually in order to track the progress of revegetation efforts. For sites planted in 2019, data were recorded on the number and species of plants outplanted, the weights and species of seed broadcast, and any natural litter/woody debris that was placed at the site. For planned restoration sites with previously established photo points, photos were repeated prior to planting, or just after planting, in order to document the appearance of the site post-disturbance relative to pre-disturbance. For unplanned sites, new photo points were developed, and photos were taken prior to planting. Repeat photo points are taken and sites are monitored once a year for three years following revegetation efforts in order to monitor the status of vegetation recovery. Data are maintained for each restoration site containing the site prescription, photo points, and monitoring forms. These files are kept in site documentation binders in the Botany office and are also located on the Botany server.

Restoration sites that were completed in 2018/2019 but had not yet been mapped with final disturbance sizes were mapped this fall using a Trimble GPS unit. These tracks provide an accurate perimeter of the post-disturbance area in order to serve as a visual aid for future crews and provide a precise measurement of the restoration area. Maps were created for all sites that had not been previously mapped, and these are on file in site documentation binders in the Botany office and located on the Botany server.

Special Status Plant Management

In the process of rehabilitating Rim Drive and implementing the Rockfall Mitigation project, many special status plant populations growing adjacent to Rim Drive have been impacted. This includes populations of rare plants such as Mt. Shasta arnica (*Arnica viscosa*), pumice grapefern (*Botrychium pumicola*), Crater Lake rockcress, and shaggy hawkweed (*Hieracium horridum*). Whitebark pine (*Pinus albicaulis*), a candidate species for listing as threatened or endangered under the federal Endangered Species Act, is widespread throughout the project area. The world's largest known population of the Crater Lake rockcress along the Watchman grade was displaced by this project. In 2018, another population of Crater Lake rockcress was disturbed at the Skell Head Overlook (Figure 12).

Figure 12. Crater Lake rockcress. Photo by Carrie Wyler.

To mitigate impacts to the Park's special status plant species, baseline information was collected on pre-disturbance special status plant populations and seed was collected from rare plants for future propagation and revegetation. Wherever possible, special status plant species were protected from construction impacts. Rare plants were salvaged and cared for at a holdover facility and salvaged plants were transplanted back into their habitat post-disturbance. Additionally, supplemental

planting of propagated rare plants was conducted, and reestablished populations were monitored to inform management (Figure 13).

Figure 13. Planting Crater Lake rockcress along West Rim Drive (left). Monitoring Crater Lake rockcress at is reestablished population site (right). Photos by Carrie Wyler.

Invasive Vegetation Management

Crater Lake National Park has assigned all its 91 non-native plant species a management priority of Low, Medium, High, 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 these 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 some time (> 10 years) and are believed to be eradicated from within Park boundaries. If any watch species are found within the Park, they receive a management priority of high. These priorities may change depending upon situation and location. For example, most of the Rim Drive environment is relatively pristine and lacking non-native plant members. In this case, medium or low priority species may be treated in this area to protect the integrity of the vegetation communities adjacent to Rim Drive. Additionally, many rare plant species are found immediately adjacent to or nearby Rim Drive; low priority species may be controlled if they threaten rare plant populations.

The control strategies for invasive plants found within the RDRR project area are containment (preventing new infestations and spread); reduction (reducing the size and extent of existing infestations); and eradication (extirpating the invasive species from the Park). Since Rim Drive contains relatively few invasive plants, invasive plant populations along Rim Drive and project staging areas often have reduction or eradication strategies. The strategy at Rim Village is containment, reduction, or eradication as this location has a persistent invasive plant problem.

In 2019, most of the project area was surveyed for non-native, invasive plant species. Roadsides were surveyed multiple times throughout the season by foot. Project staging areas (Roundtop Quarry, the Ball Diamond, Pole Bridge Creek Quarry, and the junction of East Rim Drive and Pinnacles Road) were surveyed at least two times by foot in their entirety, including access roads and around piles of materials.

When invasive plants are encountered, data are recorded including scientific name, UTM coordinates (Zone 10, NAD83 datum), total number of plants present, area occupied by invasive plants, and treatment applied to population. Invasive plants are controlled via manual or chemical methods (Figure 14) as per the Park's Invasive Vegetation Management Plan (DOI NPS 2017). All plant parts capable of reproduction are bagged and disposed of in the trash compactor at Park headquarters. Vegetative parts incapable of reproduction are left to desiccate on site unless they present logistical or aesthetic problems for Park visitors, employees, and partners.

Figure 14. Controlling an invasive grass along East Rim Drive (left). Controlling sheep sorrel (*Rumex acetosella*) at Rim village (right). Photos by Carrie Wyler.

Any new-to-CRLA non-native plant species encountered are collected as voucher specimens for the Park's herbarium. Additionally, non-native plants encountered in previously undocumented locations are collected for the Park's herbarium.

Results

Results are presented separately for each component of the RDRR project.

Revegetation

Site Prescriptions

As of November 2019, 62 restoration sites have been defined for Phase I of the RDR project, each with a unique revegetation prescription. Documentation of these prescriptions can be found on the Botany file server. Table 3 lists the 62 restoration sites, completion status, and measurements of actual disturbed areas compared to what was planned. As of 2019, the actual area disturbed was greater than three times what was planned.

While most restorations sites are recovering well, a few sites continue to need follow-up work. Site CWRD5 needs erosion issues addressed during Phase II of the Rim Drive Project before it can be revegetated. Sites NEERD2 and NEERD2.1 were obliterated pullouts immediately west of the Cleetwood Cove parking lot. However, Park visitors have been parking on these areas and creating additional disturbance due to lack of parking at the Cleetwood Cove parking lot. These sites need barriers to prevent parking impacts prior to implementation of revegetation efforts.

Restoration work has begun at site NEERD3, which is the Cleetwood Cove parking lot. Construction work at the comfort stations and ticket booth sites was not completed until the fall of 2019. Landscaping islands and beds in the parking lot have been revegetated, but these areas are heavily trampled by visitors which presents challenges to restoration. These areas will need to be assessed yearly for traffic patterns and trampling and filled in with plants as problem areas arise. Additional barriers (fencing) may be needed to protect the newly established vegetation. Installation of fencing was not possible in the front of the parking lot due to a buried gas line's unknown location. To protect young vegetation until it is large enough to be visible by parking lot users, plants were placed in groups of three and circled with large rocks to form a barrier (Figure 15). The back of the parking lot will be worked on during Phase II of the RDR project. The area presently is not big enough for large recreational vehicles pass through and their back wheels often jump the curb and damage a revegetation site. This area has been sparsely planted in areas that would not be impacted by vehicle traffic (Figure 15). Site NEERD 3.1 is the east embankment of the Cleetwood Cove parking lot and will need to be addressed in future years. It has a steep slope of pumice soil that is continuously eroding and hindering restoration efforts.

Figure 15. Plantings in groups of three with rock borders to mitigate trampling in heavily trafficked Cleetwood Cove parking lot areas (left). The area at the back of the Cleetwood Cove parking lot will be adjusted to allow for RVs to drive around the comfort station (right). Photos by Carrie Wyler.

Table 3. Size and restoration status of all designated RDRR sites as of November 2019. Pink shading indicates disturbance area was greater than planned; green shading indicates disturbance area was smaller than planned; blue shading indicates disturbance was the same size as planned. Some sites did not have accurate pre-disturbance sizes mapped and are thus indicated as "unknown;" some sites have not yet had their post-disturbance size mapped; this will occur during the 2020 field season.

Zone	Site Name	Planned Area (Ft^2)	Actual Area (Ft^2)	Difference in Planned vs. Actual Area (Ft^2)	Planted	Seeded	Planned/ Unplanned
South WRD	SWRD1	3,807	2,160	-1,647	2018	2018	Planned
	SWRD2	1,818	2,454	636	2018	2018	Planned
	SWRD3	3,024	2,988	-36	2018	2018	Planned
	SWRD4	900	1,035	135	2018	2018	Planned
	SWRD5	9,360	23,279	13,919	2019	2019	Planned
	SWRD6	1,053	4,596	3,543	2018	2018	Planned
Central WRD	CWRD1	3,465	4,419	954	2018	2018	Planned
	CWRD2	2,862	1,384	-1,478	N/A	2018	Planned
	CWRD3	Unknown	12,689	Unknown	2016/2017	2016	Planned
	CWRD4	Unknown	1,076	Unknown	2018	2018	Planned
	CWRD4.01	0	2,540	2,540	2017	2017	Unplanned
	CWRD4.02	0	464	464	2018	2018	Unplanned
	CWRD4.1	0	6,232	6,232	2016/2017	2016/2017	Unplanned
	CWRD4.2	0	807	807	2017	2017	Unplanned

Zone	Site Name	Planned Area (Ft^2)	Actual Area (Ft^2)	Difference in Planned vs. Actual Area (Ft^2)	Planted	Seeded	Planned/ Unplanned
	CWRD4.3	0	3,286	3,286	2018	2018	Unplanned
	CWRD5	4,257	1,044	3,213	N/A	***2020***	Planned
	CWRD5.1	0	755	755	N/A	2018	Unplanned
	CWRD6	4,059	1,399	2,660	2018	2018	Planned
	CWRD6.1	0	5,977	5,977	2018	2018	Unplanned
	CWRD7	1,440	3,955	2,515	2018	2018	Planned
	CWRD8	1,890	1,808	-82	2017	2017	Planned
North WRD	NWRD1	3,726	18,751	15,025	2018	2018	Planned
	NWRD2	4,005	7,136	3,131	2017	2017	Planned
	NWRD3	3,690	5,986	2,296	2018	2018	Planned
	NWRD4	1,810	2,915	1,105	2018	2018	Planned
	NWRD4.1	0	2,917	2,917	2018	2018	Unplanned
	NWRD5	2,565	2,156	-409	N/A	2018	Planned
NW ERD	NWERD1	1,500	1,453	-47	2016	2016	Planned
	NWERD1.1	0	2,045	2,045	2016	2016	Unplanned
	NWERD2	4,440	6,133	1,733	2018	2018	Planned
	NWERD2.1	0	12,464	12,464	2016	2016	Unplanned
	NWERD2.2	0	***2021***	***2021***	***2021***	***2021***	Unplanned
NW ERD	NWERD2.5	0	1,015	1,015	2019	2019	Unplanned
	NWERD3	2,601	6,589	3,988	2018	2018	Planned
	NWERD4	2,133	5,020	2,887	2018	2018	Planned
	NWERD5	7,686	9,818	2,132	2018	2018	Planned
	NWERD5.1	0	1,604	1,604	2016	2016	Unplanned
	NWERD6	3,600	2,315	-1,285	2018	2018	Planned
	NWERD7	0	2,530	2,530	2016	2016	Unplanned
	NWERD8	0	3,423	3,432	2016	2016	Unplanned
	NWERD8.1	0	1,770	1,770	N/A	2016	Unplanned
	NWERD9	0	3,514	3,514	2018	2018	Unplanned
	NWERD10	0	8,700	8,700	2016	2016	Unplanned
	NWERD10.1	0	1,005	1,005	N/A	2016	Unplanned
NE ERD	NEERD0.01	0	6,721	6,721	2016	2016	Unplanned
	NEERD0.02	0	6,255	6,255	2016	2016	Unplanned
	NEERD0.1	0	3,455	3,455	2016	2016	Unplanned
	NEERD0.15	0	1,496	1,496	2016	2016	Unplanned
	NEERD1	Unknown	16,189	Unknown	2016	2016/2017	Planned
	NEERD1.1	0	2,583	2,583	2016	2016	Unplanned
	NEERD1.2	0	4,564	4,564	N/A	2016	Unplanned
	NEERD1.25	0	3,638	3,638	2016	2016	Unplanned

Zone	Site Name	Planned Area (Ft^2)	Actual Area (Ft^2)	Difference in Planned vs. Actual Area (Ft^2)	Planted	Seeded	Planned/ Unplanned
	NEERD1.3	0	883	883	2016	2016	Unplanned
	NEERD2	2,565	N/A	N/A	N/A	N/A	Planned
	NEERD2.1	0	N/A	N/A	N/A	N/A	Unplanned
	NEERD3	7,082	7,082	0	2017	2017/2018	Planned
	NEERD3.1	0	11,711	11,711	2017	2017/2018	Unplanned
	NEERD3.2	0	4,801	4,801	2018	2018	Unplanned
	NEERD4	7,434	7,434	0	N/A	N/A	Planned
	NEERD5	2,223	2,223	0	N/A	N/A	Planned
	NEERD15	0	12,539	12,539	N/A	2017	Unplanned
	NEERD16	0	2,804	2,804	2018	2018	Unplanned
Total Planned Disturbance Area: 97,809 ft^2 (2.25 acres) Total Actual Disturbance Area: 301,137 ft^2 (6.96 acres) **Difference: 203,328 ft^2 (4.71 acres)**							

Seed Collection

Plant phenology was monitored during the season through biweekly visits to collection sites, and then later in the season concurrently with seed collection. Plant phenology progressed later than in 2018 due to a higher snowpack (434" or 89% of average in 2019 vs. 336" or 69% of average in 2018) and later snowmelt (snow-free dates at Park headquarters were June 28 in 2019 vs. May 29 in 2918) during the 2019 field season. Initial 2017 seed collection began in mid-August and continued through the end of October; while in 2018, seed collection began in mid-July and continued through early October. In 2019 seed collection commenced in early August and continued into mid-October. The peak seed collection for the bulk of plant species in most of the zones occurred from late-August to late-September (Table 4). Some plant species offered a long collection period due to multiple flowering episodes throughout the growing season.

Table 4. 2019 seed collection periods for key species indicated by gray shading.

Species	July (mid)	JULY (late)	AUG (early)	AUG (mid)	AUG (late)	SEPT (early)	SEPT (mid)	SEPT (late)	OCT (early)	OCT (mid)	OCT (late)
Achnatherum occidentalis		■	■	■	■	■		■	■		
Aconogonon davisiae var. *davisiae*				■	■	■	■	■			
Bromus carinatus var. *carinatus*				■	■	■	■	■			
Calyptridium umbellatum		■	■	■	■	■					
Carex breweri						■	■	■			

Species	JULY (late)	July (mid)	AUG (early)	AUG (mid)	AUG (late)	SEPT (early)	SEPT (mid)	SEPT (late)	OCT (early)	OCT (mid)	OCT (late)
Carex halliana											
Carex pachycarpa											
Elymus elymoides ssp. *elymoides*											
Ericameria greenei											
Ericameria nauseosa											
Juncus parryi											
Leutkea pectinata											
Lupinus andersonii											
Lupinus lepidus var. *lobbii*											
Phacelia hastata ssp. *compacta*											
Phlox diffusa											

In 2019, Botany staff collected seed from all species on the RDRR project's species collection list. Grasses and sedges produced abundant seed that was easy to collect, and thus made up the bulk of the 2019 seed collection. Species that were collected in lower quantities include lupine (*Lupinus* sp.) and pussypaws (*Calyptridium umbellatum*), as predation from unknown insects and mammals significantly reduced the quantity and quality of available seed. Additionally, spreading phlox was collected in low quantities in 2019, as the seed is difficult to collect, and the collection window was very short. Fleeceflower continued to pose a challenge for seed collection and plant propagation efforts by seed. Fertilization appears to be very patchy in the field, and while fruit development can be detected for the first few months after fertilization, many developing seeds appear to be aborted weeks before any viable seed can be acquired. Previous attempts at propagating fleeceflower suggest root division/cuttings are viable means of propagation (Trindle and Flessner 2003); however, initial tests of this method by the Corvallis PMC were largely unsuccessful. During the 2018 field season, several successful trials of propagating fleeceflower from root divisions/cuttings were conducted by the Botany program. The success of these trials establishes this method as a viable option for producing this species for future revegetation needs at CRLA (Figure 16).

Figure 16. Root division cuttings of fleeceflower (left); pots of fleeceflowers emerging from root cuttings (right). Photos by Scott Heisler.

To augment the amount of plant materials available for revegetation in both Phase I & II of this project, the seed increase services of the Meeker PMC were utilized. The Meeker PMC installed two seed increase fields for California brome (*Bromus carinatus* var. *carinatus*) and bottlebrush squirreltail (*Elymus elymoides* ssp. *elymoides*) from CRLA seed (Figure 17).

Figure 17. Bottlebrush squirreltail seed increase field (sown with CRLA seed) at the Meeker PMC in August 2019. Photo by Steve Parr.

In fall of 2015, 714 g of California brome and 2,218 g of bottlebrush squirreltail seed were sent to the Meeker PMC for seed increase. To maximize seed yield, it was agreed to combine bottlebrush squirreltail seed from all seed zones for seed increase purposes. California brome seeds were combined from the three West Rim Drive seed zones, and from the two East Rim Drive seed zones. The seeds produced at the Meeker PMC were scheduled to be collected and cleaned in 2017, 2018 and 2019. Very little seed yield was available in 2017, as the fields established slowly. Due to the large quantity of seed received from the Corvallis PMC in 2018, no seed was requested from Meeker in 2018. Twenty pounds of bottlebrush squirreltail seed and 8.4 pounds of California brome seed were shipped to the Park in the fall of 2019 for use in broadcast seed application for finishing up revegetation work on Phase I restoration sites. Large quantities of seed will be needed for restoration at Roundtop quarry during Phase II of the Rim

Drive project, therefore only small quantities were requested in 2019. Production totals from 2017-2019 are displayed in Table 5.

Table 5. Production totals from seed increase efforts by the Meeker PMC. PLS=Pure live seed.

Plant Species and Seed Zone	2017 PLS (lbs.)	2018 PLS (lbs.)	Amount PLS (lbs.) CRLA Received 2019	2019 PLS (lbs.)	Amount Available for 2020 and Phase II (lbs.)
California brome – West Rim Drive zones	1.6	66.5	0	157.5	225.6
California brome – East Rim Drive zones	91 g*	8.4	8.6	88.5	88.5
Squirreltail – all zones	9.6	123.5	20	218.5	331.6

*In 2017, the Meeker PMC's crop of California brome was stunted and produced very little seed (< 1 lb.).

Plant Care and Nursery Work

After the snow melted in 2019, plants that had been overwintered were assessed and inventoried. Plants without any green growth or with rotted roots were discarded. Certain plant species experienced substantially higher survivorship than others, with grasses, sedges and rushes having the greatest success, and species such as Sierra eriogonum (*Eriogonum marifolium* var. *marifolium*), Davidson's penstemon (*Penstemon davidsonii* var. *davidsonii*), and Greene's goldenweed (*Ericameria greenei*), experiencing high mortality. Many plants with well-developed roots were transplanted into larger containers while others with detritus, moss, liverwort, or volunteer plants were cleaned (Figure 18). Detailed reports of daily nursery activities are on file in the Botany office in the Nursery Activities binder.

Figure 18. Overwintered plants emerging from the snow in June 2019 (left). Cleaning detritus, moss, and weeds out from overwintered potted plants (right). Photos by Carrie Wyler.

Site Preparation

All areas that were unable to be restored in 2018 were completed in 2019. Sites that were available for restoration were prepared prior to planting and/or seeding as per established methods.

Planting and Seeding

In 2019, 29.8 lbs. of cleaned seed and 5,971 plants were delivered to CRLA by Corvallis PMC staff, and 28.6 lbs. of cleaned seed delivered from Meeker PMC. In 2019, all sites remaining for restoration were completed except for sites that will need to be addressed in Phase II of the project: CWRD5, NWERD2.2, NEERD 2 and 2.1, and NEERD3.1. A total of 1,705 plants were planted and 11,487 grams of seed were dispersed across the RDRR project area in 2019. Table 6 summarizes the seeding and planting accomplishments by zone for the 2019 season. The amount of seed and number of plants that each site received are detailed in Table 7. The overall status of restoration completion for the RDRR project as of November 2019 is displayed in Table 8.

Table 6. 2019 Summary of restoration planting and seeding accomplishments by seed zone.

Seed Zone	Number of Restored Sites	Total Area Restored (ft^2)	Total Area Restored (Acres)	Total Number Plants Planted	Total Grams Seeded
South WRD	3	28,721	0.66	927	6,327
Central WRD	4	28,184	0.64	84	1,161
North WRD	2	5,073	0.12	115	105
Northwest ERD	5	24,757	0.57	140	256.5
Northeast ERD	3	14,687	0.34	440	1,445
TOTAL	17	101,425	2.33	1,706	9,294.5

Table 7. Restoration planting and seeding totals for the 2019 field season.

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
South WRD	SWRD5	*Achnatherum occidentalis*	148	600
		Anaphalis margaritacea	0	1
		Bromus carinatus var. *carinatus*	147	1,000
		Calyptridium umbellatum	0	3
		Carex halliana	0	1,000
		Carex pachycarpa	0	802
		Castilleja arachnoidea	0	3
		Elymus elymoides ssp. *elymoides*	206	500
		Eremogone pumicola	0	9
		Ericameria greenei	263	214
		Eriogonum marifolium var. *marifolium*	0	543
		Eriogonum pyrolifolium var. *coryphaeum*	0	7
		Holodiscus microphyllus var. *glabrescens*	0	86

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		Juncus parryi	0	5
		Lupinus andersonii	0	170
		Lupinus lepidus var. *lobbii*	0	4
		Phlox diffusa	121	0
		Mix	0	936
		TOTAL	**885**	**5,883**
	SWRD2	*Achnatherum occidentalis*	0	100
		Bromus carinatus var. *carinatus*	0	100
		Elymus elymoides ssp. *elymoides*	0	100
		TOTAL	**0**	**300**
	SWRD3	*Ericameria greenei*	0	30
		Eriogonum pyrolifolium var. *coryphaeum*	0	41
		Holodiscus microphyllus var. *glaberscens*	0	73
		TOTAL	**0**	**144**
	SWRD6	*Ericameria greenei*	21	0
		Phlox diffusa	21	0
		TOTAL	**42**	**0**
Central WRD	CWRD3	*Boechera horizontalis*	64	0
		TOTAL	**64**	**0**
	CWRD4.1	*Boechera horizontalis*	20	0
		TOTAL	**20**	**0**
	CWRD4.3	*Achnatherum occidentalis*	0	150
		Anemone occidentalis	0	300
		Bromus carinatus var. *carinatus*	0	40
		Carex breweri	0	30
		Carex pachycarpa	0	30
		Castilleja species	0	10
		Elymus elymoides ssp. *elymoides*	0	151
		Eriogonum marifolium var. *marifolium*	0	200
		Eriogonum pyrolifolium var. *coryphaeum*	0	30
		Penstemon davidsonii var. *davidsonii*	0	20
		TOTAL	**0**	**961**
	CWRD6.1	*Anemone occidentalis*	0	200
		TOTAL	**0**	**200**
North WRD	NWRD4.1	*Achnatherum occidentalis*	0	0
		Aconogonon davisiae var. *davisiae*	42	0
		Carex breweri	0	55

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		Elymus elymoides ssp. *elymoides*	0	0
		Ericameria greenei	0	0
		Eriogonum marifolium var. *marifolium*	0	50
		Eriogonum pyrolifolium var. *coryphaeum*	0	0
		Lupinus andersonii	0	0
		Lupinus lepidus var. *lobbii*	0	0
		Penstemon davidsonii var. *davidsonii*	0	0
		TOTAL	**42**	**105**
	NWRD5	*Aconogonon davisiae* var. *davisiae*	18	0
		Eriogonum marifolium var. *marifolium*	7	0
		Eriogonum pyrolifolium var. *coryphaeum*	28	0
		Phlox diffusa	20	0
		TOTAL	**73**	**0**
NW ERD	NWERD2.5	*Achnatherum occidentalis*	14	9
		Aconogonon davisiae var. *davisiae*	21	0
		Calyptridium umbellatum	0	.5
		Carex breweri	0	15
		Castilleja applegatei	0	2
		Elymus elymoides ssp. e*lymoides*	18	20
		Eriogonum pyrolifolium var. *coryphaeum*	0	25
		Juncus parryi	0	15
		Lupinus lepidus var. *lobbii*	0	9
		TOTAL	**53**	**95.5**
	NWERD3	*Achnatherum occidentalis*	49	0
		Aconogonon davisiae var. *davisiae*	21	0
		Carex breweri	0	13
		Elymus elymoides ssp. *elymoides*	17	0
		TOTAL	**87**	**13**
	NWERD5	*Castilleja applegatei*	0	1
		Elymus elymoides ssp. *elymoides*	0	20
		Eriogonum pyrolifolium var. *coryphaeum*	0	28
		Juncus parryi	0	28
		Luetkea pectinata	0	15
		Lupinus lepidus var. *lobbii*	0	11
		TOTAL	**0**	**103**
	NWERD6	*Juncus parryi*	0	15
		Luetkea pectinata	0	20
		Lupinus lepidus var. *lobbii*	**0**	10

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		TOTAL	**0**	**45**
NE ERD	NEERD3	*Achnatherum occidentalis*	36	40
		Arctostaphylos nevadensis	99	0
		Bromus carinatus var. *carinatus*	118	25
		Carex halliana	0	319
		Carex pachycarpa	0	82
		Elymus elymoides ssp. *elymoides*	48	209
		Ericameria nauseosa var. *speciosa*	84	0
		Lupinus lepidus var. *lobbii*	0	18
		Phacelia hastata ssp. *compacta*	0	33
		Pinus contorta	1	0
		TOTAL	**386**	**1,027**
	NEERD3.2	*Achnatherum occidentalis*	21	0
		Arctostaphylos nevadensis	19	0
		TOTAL	40	0
	NEERD16	*Boechera horizontalis* (salvaged)	14	0
		Unclean seed mix	0	418
		TOTAL	**14**	**418**
		TOTAL FOR 2019	**1,706**	**9,294.5**

Table 8. RDRR project restoration completion status as of fall 2019.

Seed Zone	# Sites Restored	Total # Sites to be Restored	Fall 2019 Completion (%)
South WRD	6	0	100
Central WRD	15	1	93
North WRD	6	0	100
NW ERD	17	1	94
NE ERD	18	1	94
Total	**62**	**3**	**95**

Site Documentation and Monitoring

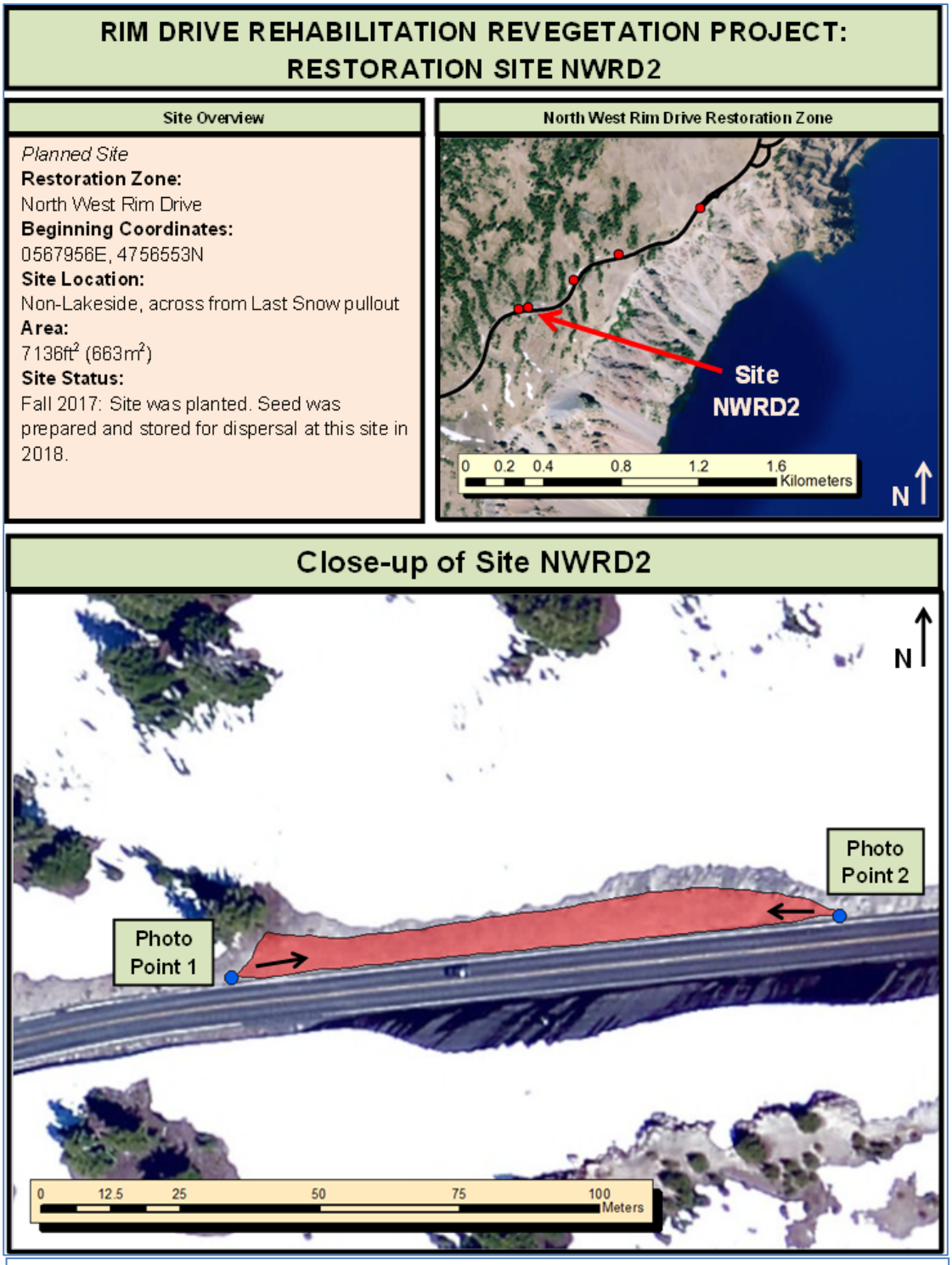
Site documentation and monitoring were completed for all sites that were restored prior to 2019. For these sites, one- two- and three-year post-restoration photo points were taken, and monitoring forms were completed as a means of assessing the success of revegetation efforts and determining additional site needs. The success of 2016, 2017, and 2018 planting and seeding was variable, with some sites having high survivorship of plantings and significant regeneration (Figure 19), while other sites still had very low overall vegetation cover. Some sites needed additional seeding and/or

planting to supplement the 2016-2018 work. However, most sites were assessed as having moderate or good regeneration and were left as-is; they will be reassessed in 2020. For sites restored in 2019, photo points were taken, and documentation forms completed to record the number of plants and grams of seed by species that were placed at each site.

Figure 19. Site NEERD0.1 in 2016 (left) and in 2019 (right). Photos by Carrie Wyler.

Overview documents (Figure 20) were created for each restoration site, including a map of the site, description of the site location, and location of photo points. These documents show the precise area and location of sites and can be used in combination with monitoring forms as a way of tracking restoration progress from year to year at each specific site. Binders for each zone were created/updated and contain site maps and monitoring documentation for each restoration site. These binders are on file in the Botany office and available for reference by future staff. Overview maps and complete site documentation forms for all sites can be found on the Botany server.

Monitoring results showed a clear pattern: restored sites that were protected from further impacts (e.g., vehicle damage, trampling) did markedly better than those that experienced additional and/or ongoing impacts. Forty-eight of the 62 restored sites are doing well, and vegetative recovery is progressing with no further action needed. The other 14 were either damaged by vehicle traffic, trampled by Park visitors, or have challenging site conditions (e.g., steep slopes, erosion, unstable soils) that make revegetation difficult. Supplemental planting and seeding in 2020 will continue to assist the recovery of restoration sites that are struggling, and some sites may need fencing and/or signage to protect recovering sites from further damage especially at the Watchman Overlook and Cleetwood Cove parking lot.



Document location: R:\BOTANY\Ecological Restoration\Rim Drive Rehabilitation project\Revegetation\ Site documentation\NWRD\Maps NWRD2.docx
ArcGIS Map location: R:\GIS_UserMaps\restoration_projects\rim_drive\Restored sites (in progress 2).mxd

Figure 20. Example of a site overview map that was created in order to aid in site documentation and assist future staff in precisely locating and monitoring restoration sites. Map by Tara Chizinski.

Monitoring data also captured the early colonization of most restoration sites that were revegetated during 2016-2019 in the RDRR project area by the native plants spreading groundsmoke (*Gayophytum diffusum*) and pussypaws. These species were not recorded during the drafting of restoration prescriptions and are serving the role of pioneering species into revegetation sites (Figure 21). To date, no other native plant species have appeared at restoration sites that were not present pre-disturbance.

Figure 21. Spreading groundsmoke (left) and pussypaws (right). Photos by Melody Frederic.

Special Status Plant Management

During the 2019 season, 64 Crater Lake rockcress plants were planted at site CWRD3, and 20 were planted at site CWRD4.1.

Invasive Vegetation Management

A total of 76,840 invasive plants were removed from project areas during the 2019 season. Invasive plants were encountered most frequently at Rim Village. Invasive plant abundances found this season are compared to 2017 and 2018 (Table 9). A map of invasive plant locations is displayed in Figure 23.

Common plantain, pineapple weed, and St. John's wort populations were treated in their entirety with all observed individuals removed. However, large invasive plant populations of yellow rocket, sheep sorrel, and white clover at Rim Village were treated as time allowed. The large population of sheep sorrel by the Crater Lake Lodge has been subject to a large control effort annually since 2013, often using volunteer groups. This site was first treated with herbicide in the fall of 2017 and was treated again in June-July 2018 and 2019. Sheep sorrel abundance was greatly reduced in 2018 and 2019, which may be attributable to the effectiveness of chemical treatment. Pineapple weed abundance

stayed about the same as last year, demonstrating that this is a challenging species to control. This species was first documented at CRLA in 2014 and has been quickly spreading throughout developed areas. Pineapple weed frequently invades restoration areas and competes with species planted for revegetation efforts. Common knotweed (*Polygonum aviculare* ssp. *depressum*) was another species that increased greatly in number for unknown reasons. This is another difficult species to treat by manual means due to its deep root systems. In 2020 this species should be treated with herbicide. Red sandspurry (*Spergularia rubra*) has become an increasingly abundant invasive species, forming mats in some disturbed areas and outcompeting native plants. In 2019, Botany staff manually removed red sandspurry from the landscape islands around the Rim Village Café and Gifts building (Figure 22). This treatment was followed up in the fall by dispersing and raking in 114g of an uncleaned seed mix (gathered from Rim Village). These areas will need to be monitored in the future and treated with herbicide before flowering in early spring, and again in late summer to control the plant during its multiple flowering periods.

Table 9. Abundance (number of plants encountered) of invasive plants within the RDRR project area for 2017, 2018, and 2019.

IVM Region	Invasive Plant Species	2017 Abundance	2018 Abundance	2019 Abundance
Pole Bridge Creek Quarry	Yellow rocket (*Barbarea vulgaris*)	10	9	95
	Red sandspurry (*Spergularia rubra*)	12	0	0
	Common dandelion (*Taraxacum officinale*)	9	0	0
East Rim Drive	Yellow rocket (*Barbarea vulgaris*)	56	2	0
	Canola (*Brassica napus*)	0	2	0
	Smooth brome (*Bromus inermis*)	5,157	130	0
	Cheat grass (*Bromus tectorum*)	1	0	0
	St. John's wort (*Hypericum perforatum*)	25	0	0
	Annual bluegrass (*Poa annua*)	40	0	0
	Canada bluegrass (*Poa compressa)*	0	0	200
	Common knotweed (*Polygonum aviculare* ssp. *depressum*)	57	0	0
	Sheep sorrel (*Rumex acetosella)*	0	0	80
	Tansy ragwort (*Senecio jacobaea*)	67	0	0
	Red sandspurry (*Spergularia rubra*)	1	0	0
	Common dandelion (*Taraxacum officinale*)	368	36	585
West Rim Drive	Sheep sorrel (*Rumex acetosella)*	0	0	12
	Timothy (*Phleum pratense*)	0	1	0
Rim Village	Yellow rocket (*Barbarea vulgaris*)	640	98	294
	Big chickweed (*Cerastium fontanum* ssp. *vulgare*)	0	1	0
	Bull thistle (*Cirsium vulgare*)	1	0	0
	Orchard grass (*Dactylis glomerata*)	2	0	0
	St. John's wort (*Hypericum perforatum*)	4	0	0
	Stinking pepperweed (*Lepidium ruderale)*	0	0	1
	Birdsfoot trefoil (*Lotus corniculatus*)	1	0	0

IVM Region	Invasive Plant Species	2017 Abundance	2018 Abundance	2019 Abundance
	Pineapple weed (*Matricaria discoidea*)	725	719	550
	English plantain (*Plantago lanceolata*)	3	1	3
	Common plantain (*Plantago major*)	17	0	3
	Annual bluegrass (*Poa annua*)	40	0	0
	Common knotweed (*Polygonum aviculare* ssp. *depressum)*	762	305	3,930
	Sheep sorrel (*Rumex acetosella)*	25,998	7,267	1,719
	Red sandspurry (*Spergularia rubra*)	16,490	6,142	69,174
	Common dandelion (*Taraxacum officinale*)	260	73	69
	White clover (*Trifolium repens*)	535	102	128
	Total	**51,281**	**14,888**	**76,840**

Figure 22. Red sandspurry (very low-growing green hue on the soil surface) prior to (left) and following manual removal (right) at Rim Village. Photos by Scott Heisler.

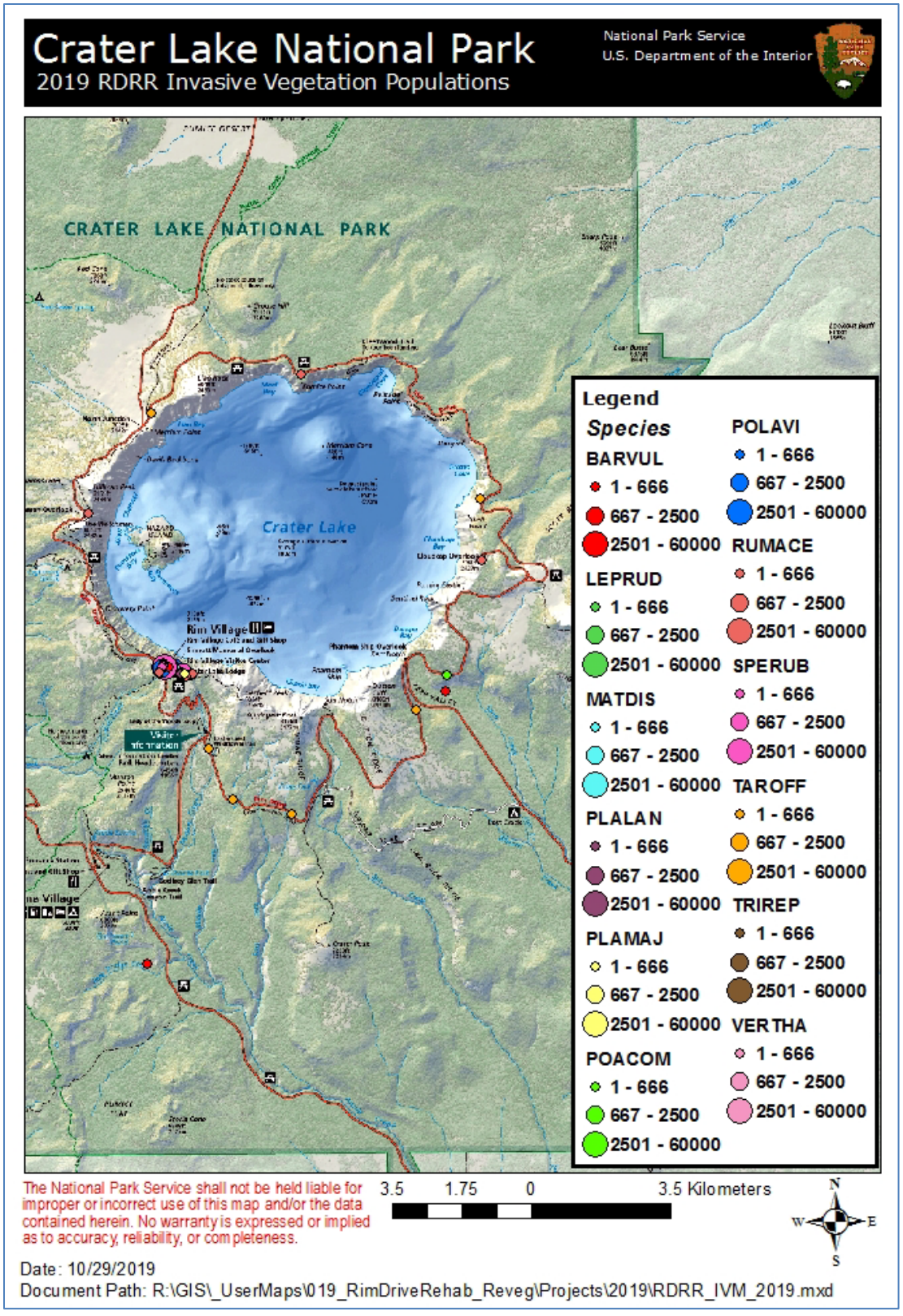


Figure 23. Map of invasive populations for the RDRR project. Map by Scott Heisler.

Discussion

During the 2019 season many of the unfished revegetation sites were completed. During 2020 efforts should focus on areas that need additional assistance with recovery such as highly visited and trampled areas. During 2019 large rock rings were made around grouped plantings at the Cleetwood Cove parking lot and the Glacial Scratches pullout areas. In 2020 these areas should be revisited to see how effective this method is to deter visitors from trampling newly planted plants. If this method proves successful more plants with rock rings should be planted at Cleetwood Cove parking lot, the Watchman Lookout parking area, and other trampled areas. Some areas may need more obvious exclusion methods such as fencing and signage. Monitoring and completing site documentation for areas that underwent restoration work during the 2015—2019 field seasons will aid in evaluating the success of these efforts. These evaluations are vital for tracking efficacy of restoration efforts, identifying areas in need of additional plant materials, and for informing managers in the planning of future restoration efforts.

In 2019, planning for Phase II of the Rim Drive Rehabilitation project commenced. Phase II will start at the Cleetwood Cove parking lot and head clockwise along East Rim Drive; the end point is presently planned for the intersection of Munson Valley Road at Park headquarters. A revegetation plan will be drafted for Phase II as soon as construction plans are complete. Then a new cycle of site documentation, revegetation prescriptions, seed collection, invasive plant survey and control, and rare plant surveys will begin in order to minimize impacts of Phase II on the Park's natural resources.

Completing restoration of sites disturbed in Phase I of the Rim Drive Rehabilitation project will occur concurrently with Phase II planning and preparation. Many sites still need to be reassessed and additional plants and seed added to fill in areas that aren't faring as well as other sites. Restoration sites that are recovering poorly due to visitor trampling or parking will need fencing or other barriers to protect fragile vegetation from foot and/or vehicle traffic. Invasive plant survey and control will continue in Phase I project areas and monitoring and site documentation of all Phase I restoration sites will continue. All remaining plant materials from Phase I will be used to help wrap up Phase I revegetation efforts.

Recommendations and needs for RDRR work in the 2020 field season include:

- All plants that overwintered in 2019/2020 need to be assessed for status and health. Root-bound plants will need to be transplanted into larger containers or divided as soon as practical after the snow melts. Plants will need fertilization to assist with survival and growth. The plants selected for overwintering were chosen because of their quick root development and overall hardiness. If plants aren't transplanted, many will die due to being extremely root-bound. Care should be taken to not expose newly transplanted plants to water, light, or temperature shock. All containerized plants should be checked for moss or liverwort growth and removed if present to prevent disease. All remaining Phase I plants should be outplanted in 2020 at sites that are still sparsely vegetated.

- Surveys in areas with previously documented invasive plant populations should be conducted several times during the growing season, with priority given to areas near rare plant populations (e.g., Diamond Lake overlook, the Watchman Overlook, Grotto Cove, and Skell Head). The entire project area needs to be thoroughly surveyed (e.g., walked) for invasive plants at least twice throughout the field season.

- Continue to survey staging areas used by the 2014 Pavement Preservation project for invasive plant species, including Pole Bridge Creek Quarry; Roundtop Quarry; the Ballfield; Cloudcap Spur Road and its intersection with East Rim Drive; the intersection of East Rim Drive and Pinnacles Road; the North Junction parking area; and the intersection of West Rim Drive with the North Entrance Road. Roads within the RDRR project area treated by the chip-seal project include Cloudcap Spur Road, the intersection of West Rim Drive with Munson Valley Road, and the intersection of East Rim Drive with Munson Valley Road.

- Areas along East Rim Drive from the Cloudcap junction to Park headquarters experienced ground disturbance in 2018 from a rock scaling and ditch cleaning project; these areas should be watched for invasive plant establishment in 2020.

- The National Weather Service has an extremely useful weather database with daily, monthly, and yearly data summaries (http://w2.weather.gov/climate/xmacis.php?wfo=mfr) that should be used to help inform when to water newly planted seedlings and provides information for seed collection. It also facilitates year-to-year comparisons by providing data on annual snow loads and precipitation amounts.

- Restoration prescriptions will need to be developed for Roundtop quarry. Its slopes were mechanically recontoured by the Phase I contractors leaving the disturbed areas completely devoid of vegetation. Much of the seed being produced at the Meeker PMC can be used at this site. Seed will need to be raked in with Park compost and native debris distributed. The area will need to be mapped, documented, and monitored in Phase II for restoration progress and surveyed diligently for invasive plant species.

- The Cleetwood Cove parking lot will continue to need revegetation in 2020, after accessing restoration success from 2019 efforts. A full visitation season will help with discovering areas where visitors cut through and create natural walking paths. This will help determine where to establish fencing so that revegetation sites can be protected from visitor trampling and given time to establish.

- The east embankment at the Cleetwood Cove parking lot will continue to need slope stabilization and erosion control for revegetation efforts to be successful. This embankment was disturbed by contractors stacking cut logs on it when they were clearing trees to expand the parking lot. The embankment is steep and consists of loose pumice soil, which collapses when walked on. The site does not hold seed or water well, and it has been difficult to restore and revegetate. In 2019 large logs and rocks were put into place and areas were vertically mulched with little success. This area needs to be reassessed in 2020 to develop a

new plan of action. Creating and burying waddles stuffed with native seed and planting behind them is a method to be considered in 2020. Every revegetation attempt creates more soil disturbance and erosion, so this need to be considered. Hall's sedge (*Carex halliana*) is presently being propagated for this area; its fibrous and extensive roots system may aid in soil stabilization.

- Forty pinemat manzanita (*Arctostaphylos nevadensis)* plants were transplanted into one gallon pots and then planted in Cleetwood Cove parking lot landscaping islands during the fall of 2019 in groups of three with a rock border. These were placed in larger pots to increase their size with the hope that trampling impacts would be lessened if vegetation cover was greater and the rock border would create a visual cue for visitors to not trample them. Pinemat manzanita plants that originated from their original (smaller than one-gallon containers) were planted in the landscaping islands in 2017 and were almost all killed from trampling impacts as of fall 2018. If this technique is successful, it would be good to use larger, older plants with rock borders in heavily trafficked areas in the future.

- Skell Head Overlook (NEERD16) will also need to be reassessed in 2020. After monitoring the site in 2019 it was discovered that approximately 5 plants out of 126 planted and 711 grams of dispersed seed survived the 2019 season. The lack of success at this restoration site may be due to the exposed nature of the site, the high wind exposure, and the fact that the contractors did not apply topsoil to this site, only gravelly subsoil. To ameliorate the harsh conditions at this site, 418g of seed was raked in, then six truck beds of Park-sourced compost were piled on top of the seed mix. A truck bed of windblown native pumice soil salvaged from paved pullouts on East Rim Drive was then dispersed on top of the compost in hopes of holding everything in place. However, five days later a storm came through the area and dispersed much of the recently applied material off the site. Much of the material was captured by the rock walls on site and was gathered and re-dispersed onto the site right before a heavy snowstorm hit the area. The area needs to be assessed in 2020 for additional methods to anchor soils and reestablish vegetation at this harsh site.

Literature Cited

Beck, J.S., A.H. Fraser, C.S. Wyler, M.C. Frederic, and K.M Williams. 2017. Rim Drive Rehabilitation Revegetation Project 2016 Annual Report. Crater Lake National Park, Crater Lake, Oregon.

Department of the Interior National Park Service. 2017. Crater Lake National Park Invasive Vegetation Management Plan Environmental Assessment. Crater Lake, Oregon.

Gregory, R., K. Stella, and J. Beck. 2015. Crater Lake National Park Revegetation Plan for Rim Drive Rehabilitation and Rockfall Mitigation Projects. Unpublished report on file at Crater Lake National Park headquarters.

Trindle, J.D. and T.R. Flessner. 2003. Propagation protocol for vegetative production of container *Polygonum davisiae* Brewer ex Gray plants (1-yr crowns in 6); USDA NRCS – Corvallis Plant Materials Center, Corvallis, Oregon. In: Native Plant Network. URL: https://npn.rngr.net/npn/propagation/protocols/polygonaceae-polygonum-2475/?searchterm=polygonum%20davisiae [accessed 25 March 2020]

The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

April 2020

National Park Service
U.S. Department of the Interior

Crater Lake National Park
P.O. Box 7
Crater Lake, Oregon 97604