



Rim Drive Rehabilitation Revegetation Project

2018 Annual Report





ON THIS PAGE

Planting native plants at Skell Head Overlook for the Rim Drive Rehabilitation project.
Photograph by Carrie Wyler.

ON THE COVER

Restoring a pullout obliterated by the Rim Drive Rehabilitation project by outplanting with native plants.
Photograph by Carrie Wyler.

Rim Drive Rehabilitation Revegetation Project

2018 Annual Report

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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.

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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. 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 2018 field season, over 14,888 invasive plants were removed from the project area. For the sixth year in a row, plant materials were collected from five distinct seed zones representing the floral diversity of the project area. Forty-seven seed accessions were provided to the Corvallis Plant Materials Center by Park staff for propagation of plants for revegetation and creation of customized seed mixes for each restoration site. Site documentation was refined for each disturbed site to inform future restoration efforts and monitor revegetation status of the project. In 2018, CRLA staff planted 1,653 native plants, 63 salvaged rare plants, and dispersed 4,910.5 grams of native seed throughout disturbed areas along East Rim Drive. On West Rim Drive, 3,307 native plants were outplanted in disturbed areas along with approximately 12 salvaged rare plants; and 22,142.5 grams of native seed were broadcast in disturbed areas along the road corridor. Scheduled road construction work was not completed until the end of this season, leaving some restoration work to be accomplished during the 2019 field season.

Acknowledgments

This project was greatly assisted by staff at the National Park Service Denver Service Center, notably Tracy Cudworth, Chris Taliga, and Ken Stella. Jim Kent of the Federal Highway Administration assisted with translating construction plans into tangible impacts that helped direct mitigation efforts and communicating changes in the project schedule and timeline. The Crater Lake National Park Maintenance staff allowed use of the Ball Diamond at Park headquarters for storing and caring for salvaged and delivered plants, and the South Yard for maintaining facilities for plant propagation and seed cleaning. The Crater Lake National Park Roads crew provided large equipment and staffing to move large items and turn piles of compost for use in restoration efforts. Planting and seeding assistance was received by members of the Crater Lake National Park Terrestrial Ecology seasonal staff, especially Thomas Hender, Alissa Iverson, Delacey Randall, Hamilton Hasty, J.C. McNelly, and Janette Perez-Jimenez. Staff at the Corvallis Plant Materials Center, especially Amy Bartow, provided technical assistance with seed collection techniques. The Klamath Inventory and Monitoring program graciously loaned two vehicles for late-season use.

Introduction

The Federal Highway Administration (FHWA)-sponsored Rim Drive Rehabilitation 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.

The first phase of this project was conducted in 2014 and focused on intensive rockfall mitigation using heavy equipment and rock scaling at Wizard Island Overlook, the Watchman, Sun Grade, Dutton Cliffs, and the Anderson Cut. The current phase (Phase I) of the Rim Drive Rehabilitation project commenced in 2015 and affects at least 6 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. Several new 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 are being modified. These modifications include obliterating unofficial pullouts (Figure 1), shrinking the footprint of excessively large parking areas, and installing



Figure 1. User-created pullout before (left; photo by Jen Hooke) and after (right; photo by Tara Chizinski) obliteration as part of the Rim Drive Rehabilitation project.

landscaping islands in high visitor use areas. Additionally, road work displaced the world's largest known population of the Crater Lake rockcress (*Boechea horizontalis*), a rare plant that is a Species of Concern on the federal endangered species list, 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 as necessary.

Restoration of areas disturbed by the Rim Drive Rehabilitation project (Figure 2) is necessary to jumpstart natural succession of vegetation communities and will help 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.

As of November 2018, road construction crews completed deep patch operations on East Rim Drive; rehabilitated West Rim Drive from Rim Village north to North Junction; and completed the Rim Village parking area. Work on the Cleetwood Cove parking lot was not complete as of November 2018. All nine pullouts along East Rim Drive and 14 along West Rim Drive have now been obliterated. Road construction work in 2018 facilitated revegetation efforts by obliterating all remaining pullouts; completing the Cleetwood Cove trailhead renovations; finishing renovation of the Watchman Overlook; rehabilitating Roundtop Quarry and other staging areas; and finishing up other sites within the project area. The types of areas to be restored along with their restoration status are listed in Table 1.

Table 1. RDRR restoration areas by location and completion status as of November 2018*.

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	No (7/8)
	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)	2	No (1/2)
	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	No (15/17)

**Additional disturbance areas may be added during the 2019 season as a complete assessment was not feasible in 2018.*

As the RDRR project progressed, the overall disturbance footprint became significantly larger than the one expected and planned for, 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) were devoted to the RDRR project in 2018; season length was from April 30 – October 25. 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. Efforts made by the RDRR program in 2018 can be organized into three components: (1) revegetation; (2) special status plant management; and (3) invasive vegetation management; these are described below.

Methods

Methods for each component of the RDRR program are discussed separately.

Revegetation

Site Prescriptions

Prior to construction and beginning in 2012, revegetation prescriptions were developed for each area slated for restoration (Figure 3). 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 from which 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 2018 RDRR crew continued to develop prescriptions and make adjustments as unanticipated ground disturbance necessitated the addition of new restoration sites. In unplanned disturbance sites, the pre-disturbance vegetation community was destroyed and unavailable for use as



Figure 3. Developing revegetation prescriptions for disturbed areas. Photo by Carrie Wyler.

a reference; hence, revegetation prescriptions were developed from adjacent 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 and 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 a couple of species additions were approved to help fill any gaps in the species accession list. Some additional species were collected by CRLA staff during the 2018 season, with the intention that this extra seed would be cleaned by Park staff and returned to sites in the same season. Table 2 lists all species collected during the 2018 field season.

The seed collection process commenced in 2018 by observing and documenting the phenology of each targeted species at each revegetation site within each seed zone. 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 in Botany program files (R:\Botany\Ecological Restoration\Rim Drive Rehabilitation Project\Seed Collection\Seed Collection\2017\maps). Each seed zone has sites containing large populations of each species that crews collected from in 2018 (Appendix A).

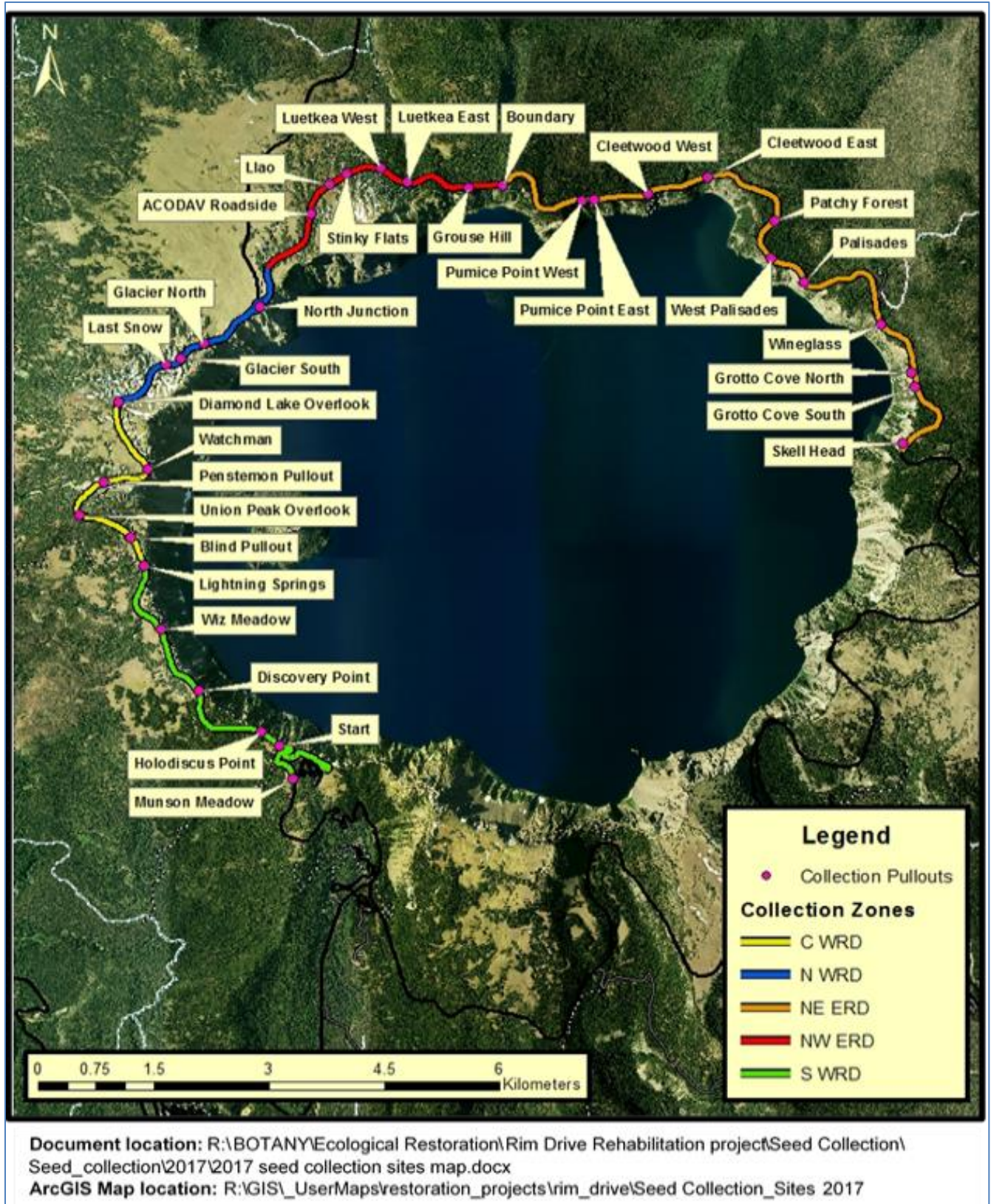


Figure 4. Seed collection zones with notable pullouts indicated. Map by Tara Chizinski.

Table 2. 2018 seed collection species list per seed collection zone.

ZONE	PLANT SPECIES NAME	
South WRD	<i>Achnatherum occidentale</i> <i>Anaphalis margaritacea</i> <i>Boechera howellii</i> <i>Bromus carinatus</i> var. <i>carinatus</i> <i>Calyptridium umbellatum</i> <i>Carex halliana</i> <i>Carex pachycarpa</i> <i>Elymus elymoides</i> ssp. <i>elymoides</i> <i>Elymus glaucus</i> ssp. <i>glaucus</i>	<i>Eremogone pumicola</i> <i>Ericameria greenei</i> <i>Eriogonum marifolium</i> var. <i>marifolium</i> <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> <i>Eucephalus ledophyllus</i> <i>Holodiscus microphyllus</i> var. <i>glabrescens</i> <i>Lupinus andersonii</i> <i>Phlox diffusa</i>
Cental WRD	<i>Achnatherum occidentale</i> <i>Aconogonon davisiae</i> var. <i>davisiae</i> <i>Anaphalis margaritacea</i> <i>Calyptridium umbellatum</i> <i>Carex brewerrii</i> <i>Castilleja applegatei</i> <i>Castilleja arachnoidea</i>	<i>Elymus elymoides</i> ssp. <i>elymoides</i> <i>Ericameria greenei</i> <i>Eriogonum marifolium</i> var. <i>marifolium</i> <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> <i>Penstemon davidsonii</i> var. <i>davidsonii</i> <i>Phlox diffusa</i>
North WRD	<i>Achnatherum occidentale</i> <i>Aconogonon davisiae</i> var. <i>davisiae</i> <i>Anaphalis margaritacea</i> <i>Calyptridium umbellatum</i> <i>Carex breweri</i> <i>Castilleja applegatei</i> <i>Castilleja arachnoidea</i> <i>Elymus elymoides</i> ssp. <i>elymoides</i>	<i>Eremogone pumicola</i> <i>Eriogonum marifolium</i> var. <i>marifolium</i> <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> <i>Eucephalus ledophyllus</i> <i>Lupinus andersonii</i> <i>Lupinus lepidus</i> var. <i>lobbii</i> <i>Penstemon davidsonii</i> var. <i>davidsonii</i> <i>Phlox diffusa</i>
NW ERD	<i>Achnatherum occidentale</i> <i>Aconogonon davisiae</i> var. <i>davisiae</i> <i>Calyptridium umbellatum</i> <i>Carex breweri</i> <i>Castilleja arachnoides</i> <i>Elymus elymoides</i> ssp. <i>elymoides</i> <i>Eremogone pumicola</i>	<i>Eriogonum marifolium</i> var. <i>marifolium</i> <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> <i>Juncus parryi</i> <i>Luetkea pectinata</i> <i>Lupinus lepidus</i> var. <i>lobbii</i> <i>Phacelia hastata</i> ssp. <i>compacta</i>
NE ERD	<i>Achnatherum occidentale</i> <i>Bromus carinatus</i> var. <i>carinatus</i> <i>Calyptridium umbellatum</i> <i>Carex halliana</i> <i>Carex pachycarpa</i> <i>Elymus elymoides</i> ssp. <i>elymoides</i>	<i>Ericameria nauseosa</i> var. <i>speciosa</i> <i>Lupinus lepidus</i> var. <i>lobbii</i> <i>Diplacus nanus</i> <i>Penstemon speciosus</i> <i>Phacelia hastata</i> ssp. <i>compacta</i>

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



Figure 5. Collecting seed on West Rim Drive. Photo by Carrie Wyler.

headquarters (Figure 6). When seeds arrived at this facility, records were kept for each species with collection dates, specific collection location, and seed zone. Seeds were then dumped inside 30-gallon plastic storage totes secured with window screen at the top, allowing ventilation while reducing chances of predation. Plant species that spilled 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.

Plant Care and Nursery Work

Due to early and abundant snowfall in October of 2017, many plants were unable to be planted and several thousand plants from the 2016 delivery continued to be overwintered at the Ball Diamond near Park headquarters. These plants required care and maintenance throughout the 2018 field season. Once the snow melted in June, plants were covered with a shade house (40' x 20' x 10' – Figure 7). The plants were fertilized 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



Figure 6. Seed drying and storage facility in the Stall Nine garage. Photo by Melody Frederic.

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. Any particularly root bound plants, including many grasses, sedges, phlox (*Phlox diffusa*), and manzanita (*Arctostaphylos* sp.), were potted up into larger containers or divided. The full details of which plants were transplanted can be found in the “Nursery Activities” Binder on file at Park headquarters.



Figure 7. Shadehouse used to house plants held over from 2016/2017. Photos by Carrie Wyler.

As of November 2018, despite a successful planting season, many plants are being held over through another winter at the Ball Diamond. 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 2019 including watering, fertilization, and transplanting into larger containers.



Figure 8. Plants being prepared for another overwintering period. Photo 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 dehiscid 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.

The road construction contractors were responsible for placing boulders on many restoration sites in order to prevent visitors from parking in these areas. Boulder placement was expected to look natural and not provide a distraction from the surrounding landscape. Where necessary, crews moved boulders and added some rocks in order to improve the aesthetics of the site and prevent cars from being parked on the edges of restoration areas (Figure 9).



Figure 9. Some sites had boulders placed that did not look natural (top left, bottom left) and/or were left with an excessive amount of gravel at the site (top right). The Botany crew adjusted sites as needed prior to planting/seeding. Photos by Tara Chizinski and Jen Hooke.

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 (Figure 10). 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 (Figure 10). The compost was, and will continue to be, used on restoration sites.



Figure 10. A screen plant was used to sort readily compostable materials (left) from partially composted woody debris to augment conditions at disturbed sites. Photo by Jen Hooke. Compost is routinely turned (right) to aid in decomposition. 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 the prescriptions and actual availability of plant materials. After planting, compost was added and plants were watered. 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). The plants were watered from a truck mounted tank until they received precipitation.



Figure 11. Site specific seed mix (left). Raking seed into a restoration site (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 12). After mulching, the plants were watered at least once. A 200 gallon water tank was mounted in the bed of a truck on a wooden pallet and used in conjunction with an electric pump to facilitate watering of newly planted plugs (Figure 12).



Figure 12. Upper left: Building a berm for a plant. Upper right: Recently installed plants with compost and soil berms to contain water. Photos by Tara Chizinski. Bottom: Truck-mounted water tank used to water newly planted and mulched plants. Photo 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 2018 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 2018, 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 will continue to be taken and sites will be monitored once a year 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 at CRLA, and are also located on the Botany program drive (R:\BOTANY\Ecological Restoration\Rim Drive Rehabilitation project\Revegetation\Site documentation).

Restoration sites that were completed in 2018 had not yet been mapped with final disturbance sizes, and were mapped this fall using a Trimble 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. New maps were made for any 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 program drive (R:\BOTANY\Ecological Restoration\Rim Drive Rehabilitation project\Revegetation\Site documentation).

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 13).



Figure 13. The Crater Lake rockcress at Skell Head Overlook. Photo by Melody Frederic.



Figure 14. Transplanting a salvaged Crater Lake rockcress back at the Skell Head overlook after construction disturbance. 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 (Figure 14). Additionally, supplemental planting of propagated rare plants was conducted, and reestablished populations were monitored to inform management.

Invasive Vegetation Management

Crater Lake National Park has assigned all of its 89 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 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 2018, the majority of the project area was surveyed for non-native, invasive plant species. Roadsides were surveyed multiple times throughout the season by foot as dictated by access (portions of West Rim Drive were difficult to access due to active road construction). 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 15) 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.

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.



Figure 15. Area signed after herbicide treatment near the Crater Lake Lodge. Photo by Carrie Wyler.

Results

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

Revegetation

Site Prescriptions

In 2018, prescriptions were developed for seven new disturbance sites. These were unplanned areas created during 2018 construction. As of November 2018, 62 restoration sites have been designated, each with a unique revegetation prescription. Documentation of these prescriptions can be found in Botany program files (R:\BOTANY\Ecological Restoration\Rim Drive Rehabilitation project\Revegetation\Site documentation). Table 3 lists the 62 restoration sites, their names, completion status, and measurements of actual disturbed areas compared to what was planned. As of 2018, the actual area disturbed was greater than three times what was planned.

Table 3. Size and restoration status of all designated RDRR sites as of November 2018. Pink shading indicates disturbance area was greater than planned; green shading indicates disturbance area was smaller than planned; blue shading indicates disturbance was 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 2019 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
	CWRD4.3	0	3,286	3,286	2018	2018	Unplanned
	CWRD5	4,257	1,044	3,213	N/A	2019	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	2019	2019	2019	2019	Unplanned

Table 3 (continued).

Zone	Site Name	Planned Area (Ft ²)	Actual Area (Ft ²)	Difference in Planned vs. Actual Area (Ft ²)	Planted	Seeded	Planned/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
	NEERD1.3	0	883	883	2016	2016	Unplanned
	NEERD2	2,565	2019	2019	2019	2019	Planned
	NEERD2.1	0	2019	2019	2019	2019	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	2019	2019	2019	2019	Planned
	NEERD5	2,223	2019	2019	2019	2019	Planned
	NEERD15	0	12,539	12,539	N/A	2017	Unplanned
NEERD16	0	2,804	2,804	2018	2018	Unplanned	
<p>Total Planned Disturbance Area: 97,809 ft² (2.25 acres) Total Actual Disturbance Area: 301,137 ft² (6.96 acres) Difference: 203,328 ft² (4.71 acres)</p>							

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 earlier due to a lower snowpack and earlier snowmelt during the 2018 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. The peak seed collection for the bulk of plant species in most of the zones occurred from late-July to mid-September (Table 4). Some plant species offered a long collection period due to multiple flowering episodes throughout the growing season.

In 2018, Botany staff collected seed from all species on the RDRR project's species collection list. Grasses, sedges, and buckwheat (*Eriogonum* sp.) species produced abundant seed that was easy to collect, and thus made up the bulk of 2018 seed collection. Species that were collected in lower quantities include lupine (*Lupinus* sp.) and paintbrush (*Castilleja* sp.), as predation from unknown insects and mammals significantly reduced the quantity and quality of available seed for these species. Additionally, phlox was collected in low quantities in 2018, as the seed matured much earlier than expected and the collection window was very short. Fleeceflower (*Aconogonon davisiae* var. *davisiae*) continued to pose a challenge for seed collection and plant propagation efforts. 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 (Figure 16) are viable means of propagation (Trindle and Fessner 2003); however, initial tests of this method by the Corvallis PMC were largely unsuccessful. Crater Lake NP Botany staff are currently experimenting with this method, and attempting to propagate fleeceflower in 20 Jumbo cones.



Figure 16. Sprouting root fragments of fleeceflower (left); pots of fleeceflowers emerging from root cuttings (right). Photos by Corvallis PMC.

Table 4. 2018 collection periods for key collection 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)
<i>Achnatherum occidentale</i>											
<i>Aconogonon davisiae</i> var. <i>davisiae</i>											
<i>Bromus carinatus</i> var. <i>carinatus</i>											
<i>Calyptridium umbellatum</i>											
<i>Carex breweri</i>											
<i>Carex halliana</i>											
<i>Carex pachycarpa</i>											
<i>Castilleja applegatei</i>											
<i>Elymus elymoides</i> ssp. <i>elymoides</i>											
<i>Ericameria greenei</i>											
<i>Ericameria nauseosa</i>											
<i>Ericameria marifolium</i> var. <i>marifolium</i>											
<i>Ericameria pyrolifolium</i> var. <i>coryphaeum</i>											
<i>Eucephalus ledophyllus</i>											
<i>Holodiscus microphyllus</i> var. <i>glabrescens</i>											
<i>Juncus parryi</i>											
<i>Leutkea pectinata</i>											
<i>Lupinus andersonii</i>											
<i>Lupinus lepidus</i> var. <i>lobbii</i>											
<i>Penstemon davidsonii</i> var. <i>davidsonii</i>											
<i>Phacelia hastata</i> ssp. <i>compacta</i>											
<i>Phlox diffusa</i>											

To mitigate for the increased levels of disturbance in this project, the seed increase services of the Meeker PMC were used to increase the abundance of plant materials available for restoration (Figure 17). In fall of 2015, 714 g of California brome (*Bromus carinatus* var. *carinatus*) and 2,218 g of squirreltail (*Elymus elymoides* ssp. *elymoides*) seed were sent to the Meeker PMC for seed increase. To maximize seed yield, it was agreed to combine squirreltail seeds from all seed zones for seed



Figure 17. Squirreltail seed increase field at the Meeker PMC. Photo by Meeker PMC.

increase purposes. California brome seeds were combined from the three West Rim Drive seed zones, and also 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, and shipped to the Park in the fall of 2018 and 2019 for use in broadcast seed application for restoration. Due to the large quantity of seed received from the Corvallis PMC and available for use in 2018, no seed was requested from Meeker this year. Production totals from 2017 and 2018, and the amount of available seed for 2019 is 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.) (Estimate)	Amount CRLA Received 2018	Estimated Amount Available for 2019 (lbs.)
California brome – West Rim Drive zones	N/A	15*	0	15
California brome – East Rim Drive zones	N/A	5*	0	5
Squirreltail – all zones	8.4	50	0	58.4

**In 2017, the Meeker PMC’s crop of California brome was stunted and produced very little seed (< 1 lb.). The PLS seed numbers for 2018 are estimates because this seed has been harvested, but not yet cleaned.*

Plant Care and Nursery Work

After the snow melted in 2018, 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 *Eriogonum marifolium* var. *marifolium*, *Penstemon davidsonii* var. *davidsonii*, *Lupinus lepidus* var. *lobbii*, *Ericameria greenei*, *Ericameria nauseosa* var. *speciosa*, and *Luetkea pectinata* experiencing high mortality. To partially make up for some of the losses, some grasses and rushes with substantially developed roots were divided. Additionally, many plants with well-developed roots were potted into larger containers (Figure 18). Detailed reports of daily nursery activities are on file in the Botany office in the Nursery Activities binder.

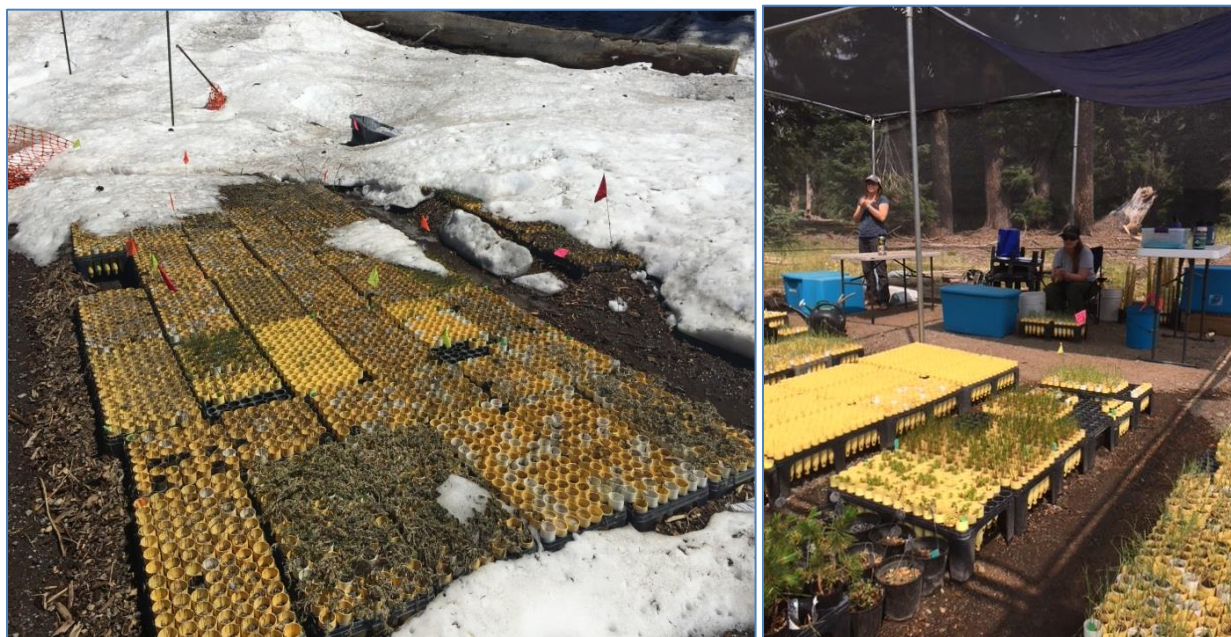


Figure 18. Overwintered plants emerging from the snow in June 2018 (left). Dividing plants with sturdy root systems (right). Photos by Carrie Wyler.

Site Preparation

Many areas that were unable to be restored in 2017 were completed in 2018. Sites that were available for restoration were prepared prior to planting and/or seeding as per established methods.

Planting and Seeding

In 2018, 107.6 lbs. of cleaned seed and 6,000 plants were delivered to CRLA by Corvallis PMC staff. Due to mild fall weather and the fact that the contractors were able to complete most sites by early-mid October, the Botany crew was able to make substantially more progress towards the revegetation of disturbed areas in 2018 compared to 2017. In total, 28 sites received initial or supplemental seeding and planting. A total of 4,960 plants were planted and 27,053 grams of seed were dispersed across the RDRR project area. Table 6 summarizes the seeding and planting accomplishments by zone for the 2018 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 2018 is displayed in Table 8.

Table 6. 2018 Summary of restoration planting and seeding accomplishments by zone.

Zone	Number of Restored Sites	Total Area Restored (ft ²)	Total Area Restored (Acres)	Total Number Planted	Total Grams Seeded
South WRD	5	13,233	0.30	790	10,218.5
Central WRD	9	22,715	0.52	1,093	6,127
North WRD	5	32,725	0.75	1,362	5,185
Northwest ERD	6	33,389	0.77	1,266	2,992
Northeast ERD	3	23,594	0.54	387	1,918.5
TOTAL	28	125,656	2.88	4,898	26,441

Table 7. Restoration planting and seeding totals for the 2018 field season.

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
South WRD	SWRD1	<i>Achnatherum occidentale</i>	52	600
		<i>Anaphalis margaritacea</i>	0	0.25
		<i>Boechera howellii</i>	0	2.5
		<i>Bromus carinatus</i> var. <i>carinatus</i>	38	500
		<i>Calyptridium umbellatum</i>	0	3
		<i>Carex halliana</i>	0	250
		<i>Carex pachycarpa</i>	0	200
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	52	250
		<i>Elymus glaucus</i> ssp. <i>glaucus</i>	0	45
		<i>Eremogone pumicola</i>	0	11
		<i>Ericameria greenei</i>	0	100
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	294
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	7.5
		<i>Eucephalus ledophyllus</i>	0	6
		<i>Juncus parryi</i>	0	4.5
<i>Lupinus andersonii</i>	0	130		
<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	3		
		TOTAL	142	2,406.75
	SWRD2	<i>Achnatherum occidentale</i>	60	600
		<i>Anaphalis margaritacea</i>	0	0.25
		<i>Boechera howellii</i>	0	2.5

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Bromus carinatus</i> var. <i>carinatus</i>	74	500
		<i>Calyptridium umbellatum</i>	0	3
		<i>Carex halliana</i>	0	250
		<i>Carex pachycarpa</i>	0	200
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	60	250
		<i>Elymus glaucus</i> ssp. <i>glaucus</i>	0	45
		<i>Eremogone pumicola</i>	0	11
		<i>Ericameria greenei</i>	0	100
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	294
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	7.5
		<i>Eucephalus ledophyllus</i>	0	6
		<i>Juncus parryi</i>	0	4.5
		<i>Lupinus andersonii</i>	0	130
		<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	3
		TOTAL	194	2406.75
	SWRD3	<i>Achnatherum occidentale</i>	81	430
		<i>Bromus carinatus</i> var. <i>carinatus</i>	70	552
		<i>Calyptridium umbellatum</i>	0	0.5
		<i>Carex halliana</i>	0	275
		<i>Carex pachycarpa</i>	0	256
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	86	475
		<i>Ericameria greenei</i>	0	128
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	190
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	8
		<i>Eucephalus ledophyllus</i>	0	5
		<i>Holodiscus microphyllus</i> var. <i>glaberscens</i>	0	67
		<i>Lupinus andersonii</i>	0	130
		<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	1
		TOTAL	237	2,517.5
	SWRD4	<i>Achnatherum occidentale</i>	28	0
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	21	0
		Custom seed mix (various species)	0	203
		TOTAL	49	203
	SWRD6	<i>Achnatherum occidentale</i>	49	570
		<i>Bromus carinatus</i> var. <i>carinatus</i>	63	662
		<i>Calyptridium umbellatum</i>	0	2.5
		<i>Carex breweri</i>	0	1

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Carex halliana</i>	0	325
		<i>Carex pachycarpa</i>	0	244
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	56	325
		<i>Ericameria greenei</i>	0	124
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	285
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	8
		<i>Eucephalus ledophyllus</i>	0	3
		<i>Lupinus andersonii</i>	0	130
		<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	5
		TOTAL	168	2,684.5
Central WRD	CWRD1	<i>Achnatherum occidentale</i>	14	260
		<i>Boechera horizontalis</i>	98	0
		<i>Carex halliana</i>	0	200
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	63	200
		<i>Ericameria greenei</i>	0	25
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	100
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	20
		<i>Juncus parryi</i>	0	0.5
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	40	3
		<i>Phlox diffusa</i>	0	0
		TOTAL	215	808.5
	CWRD2	<i>Castilleja applegatei</i>	0	8
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	40
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	10
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	0	45
		TOTAL	0	103
	CWRD4	<i>Achnatherum occidentale</i>	11	50
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	9	0
		<i>Anemone occidentalis</i>	0	200
		<i>Boechera horizontalis</i>	19	5
		<i>Boechera horizontalis</i> (salvaged)	12	0
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	16	30
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	100
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	40	15
		<i>Phlox diffusa</i>	10	3
		TOTAL	117	403
	CWRD4.02	<i>Achnatherum occidentale</i>	0	30

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	4	0
		<i>Anemone occidentalis</i>	0	100
		<i>Boechera horizontalis</i>	14	3
		<i>Castilleja applegatei</i>	0	2
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	12	30
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	3	10
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	0	30
		<i>Phlox diffusa</i>	6	0
		TOTAL	39	205
	CWRD4.3	<i>Boechera horizontalis</i>	35	0
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	10	0
		<i>Phlox diffusa</i>	28	0
		Custom seed mix (various species)	0	312
		TOTAL	73	312
	CWRD5.1	<i>Achnatherum occidentale</i>	0	30
		<i>Anemone occidentalis</i>	0	400
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	0	100
		<i>Ericameria greenei</i>	0	10
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	30
		TOTAL	0	570
	CWRD6	<i>Achnatherum occidentale</i>	34	0
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	20	30
		<i>Anemone occidentalis</i>	0	300
		<i>Boechera horizontalis</i>	49	0
		<i>Castilleja applegatei</i>	0	3
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	35	100
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	100
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	9	15
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	0	55
		<i>Phlox diffusa</i>	20	0
		TOTAL	167	603
	CWRD6.1	<i>Achnatherum occidentale</i>	64	300
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	47	35
		<i>Anemone occidentalis</i>	0	600
		<i>Boechera horizontalis</i>	49	0
		<i>Carex breweri</i>	0	5
		<i>Carex halliana</i>	0	100

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Castilleja applegatei</i>	0	2
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	63	519
		<i>Ericameria greenei</i>	0	70
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	400
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	37	61
		<i>Juncus parryi</i>	0	0.5
		<i>Phlox diffusa</i>	55	17
		TOTAL	315	2,109.5
	CWRD7	<i>Achnatherum occidentale</i>	11	200
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	15	20
		<i>Anemone occidentale</i>	0	250
		<i>Boechera horizontalis</i>	63	0
		<i>Carex breweri</i>	0	3
		<i>Carex halliana</i>	0	100
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	46	250
		<i>Ericameria greenei</i>	0	40
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	125
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	12	25
		<i>Phlox diffusa</i>	20	0
		TOTAL	167	1,013
North WRD	NWRD1	<i>Achnatherum occidentale</i>	0	250
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	55	20
		<i>Arnica vicosa</i> (salvaged)	3	0
		<i>Carex breweri</i>	275	130
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	220	400
		<i>Ericameria greenei</i> (uncleaned)	0	61
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	28	1,000
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	98	35
		<i>Lupinus andersonii</i>	0	100
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	100
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	16	40
		<i>Phlox diffusa</i>	0	8
		Custom seed mix (various species)	0	465
		TOTAL	695	2,609
	NWRD3	<i>Achnatherum occidentale</i>	0	100
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	63	10
		<i>Castilleja arachnoidea</i>	0	1

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Carex breweri</i>	111	75
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	134	148
		<i>Ericameria greenei</i>	0	15
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	400
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	21	10
		<i>Lupinus andersonii</i>	0	25
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	25
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	20	10
		<i>Phlox diffusa</i>	0	5
		TOTAL	349	824
	NWRD4	<i>Achnatherum occidentale</i>	0	100
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	35	10
		<i>Castilleja arachnoidea</i>	0	1
		<i>Carex breweri</i>	98	75
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	56	148
		<i>Ericameria greenei</i>	0	15
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	400
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	77	10
		<i>Lupinus andersonii</i>	0	25
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	25
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	11	10
		<i>Phlox diffusa</i>	0	5
		TOTAL	277	824
	NWRD4.1	<i>Achnatherum occidentale</i>	0	50
		<i>Carex breweri</i>	41	30
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	0	100
		<i>Ericameria greenei</i>	0	18
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	300
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	5
		<i>Lupinus andersonii</i>	0	20
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	25
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	0	5
		TOTAL	41	553
	NWRD5	<i>Achnatherum occidentale</i>	0	75
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	0	5
		<i>Calyptridium umbellatum</i>	0	1
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	0	50

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	200
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	5
		<i>Lupinus andersonii</i>	0	10
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	25
		<i>Phlox diffusa</i>	0	4
		TOTAL	0	375
NW ERD	NWERD2	<i>Achnatherum occidentale</i>	0	40
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	0	10
		<i>Bromus carinatus</i> var. <i>carinatus</i>	0	25
		<i>Castilleja arachnoidea</i>	0	5
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	63	175
		<i>Ericameria greenei</i>	0	21
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	460
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	10
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	5
		TOTAL	63	751
	NWERD3	<i>Achnatherum occidentale</i>	14	0
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	7	15
		<i>Boechera howellii</i> / <i>Penstemon davidsonii</i>	0	4
		<i>Bromus carinatus</i> var. <i>carinatus</i>	0	100
		<i>Calyptridium umbellatum</i>	0	1
		<i>Carex breweri</i>	0	26
		<i>Castilleja arachnoidea</i>	0	6
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	196	150
		<i>Eremogone pumicola</i>	0	17
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	40
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	30
		<i>Juncus parryi</i>	49	36
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	3
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	1	0
		<i>Phacelia hastata</i> ssp. <i>compacta</i>	3	0
		TOTAL	270	428
	NWERD4	<i>Achnatherum occidentale</i>	25	0
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	7	15
		<i>Boechera howellii</i> / <i>Penstemon davidsonii</i>	0	4
		<i>Bromus carinatus</i> var. <i>carinatus</i>	0	100
		<i>Calyptridium umbellatum</i>	0	1

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Carex breweri</i>	0	27
		<i>Castilleja arachnoidea</i>	0	5
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	172	150
		<i>Eremogone pumicola</i>	0	17
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	40
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	30
		<i>Juncus parryi</i>	49	32
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	1	2
		<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	1	0
		<i>Phacelia hastata</i> ssp. <i>compacta</i>	2	0
		TOTAL	257	423
	NWERD5	<i>Achnatherum occidentale</i>	18	17
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	12	10
		<i>Bromus carinatus</i> var. <i>carinatus</i>	0	75
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	196	128
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	50
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	30
		<i>Juncus parryi</i>	98	50
		<i>Luetkea pectinata</i>	42	89
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	5
		Custom seed mix (various species)	0	396
		TOTAL	366	850
	NWERD6	<i>Achnatherum occidentale</i>	10	0
		<i>Aconogonon davisiae</i> var. <i>davisiae</i>	5	20
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	98	50
		<i>Juncus parryi</i>	28	75
		<i>Luetkea pectinata</i>	49	125
		TOTAL	190	270
	NWERD9	<i>Achnatherum occidentale</i>	7	25
		<i>Bromus carinatus</i> var. <i>carinatus</i>	0	75
		<i>Carex breweri</i>	0	20
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	113	130
		<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	20
		TOTAL	120	270
NE ERD	NEERD3	<i>Arctostaphylos patula</i>	7	0
		TOTAL	7	0
	NEERD3.1	<i>Achnatherum occidentale</i>	0	100

Table 7 (continued).

Zone	Restoration Site	Species	Number Planted	Grams of Seed Dispersed
		<i>Arctostaphylos patula</i>	27	0
		<i>Bromus carinatus</i> var. <i>carinatus</i>	0	180
		<i>Calyptridium umbellatum</i>	0	0.5
		<i>Carex halliana</i>	0	379
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	0	317
		<i>Ericameria nauseosa</i> var. <i>speciosa</i>	0	80
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	50
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	10
		<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	30
		TOTAL	27	1,146.5
	NEERD3.2	<i>Achnatherum occidentale</i>	0	53
		<i>Arctostaphylos nevadensis</i>	74	0
		<i>Bromus carinatus</i> var. <i>carinatus</i>	98	72
		<i>Carex halliana</i>	0	330
		<i>Diplacus nanus</i>	0	8
		<i>Elymus elymoides</i> ssp. <i>elymoides</i>	161	200
		<i>Ericameria nauseosa</i> var. <i>speciosa</i>	20	58
		<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	35
		<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	7
		<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	9
		TOTAL	353	772
TOTAL FOR 2018			4,898	26,441

Table 8. RDRR project restoration completion status as of fall 2018.

Seed Zone	# Sites Restored	Total # Sites to be Restored	Fall 2018 Completion (%)
South WRD	5	6	83.3
Central WRD	14	15	93.3
North WRD	6	6	100.0
NW ERD	15	17	88.2
NE ERD	14	18	77.8
Total	54	62	87.1

In 2018, 5,103 plants were not able to be planted and are overwintering at the Ball Diamond for planting in fall 2019. Table 9 shows the numbers of remaining plants and seed by plant species that were available before the 2018 planting and those that will be available for use in 2019 and beyond.

Table 9. Plant and seed availabilities for 2019.

Plant Species	2018 Plants Available Before Planting (#)	Plants Remaining After Planting for 2019 (#)	2018 Seed Available Before Planting (g)	2018 Seed Collection by Park staff (g)	Seed in Storage Available for 2019 (g)
South WRD Seed Zone					
<i>Achnatherum occidentale</i>	1,215	945	4,386.9	67	1,542
<i>Aconogonon davisiae</i> var. <i>davisiae</i>	0	0	7.5	0	7.5
<i>Anaphalis margaritacea</i>	0	0	7.8	0.9	0.9
<i>Bromus carinatus</i> var. <i>carinatus</i>	1,015	771	5,509.9	321	4,604
<i>Calyptidium umbellatum</i>	0	0	8.2	0	0
<i>Carex halliana</i>	0	0	4,052.5	234	4,070
<i>Carex pachycarpa</i>	0	0	2,583.0	345	1,145
<i>Castilleja arachnoidea</i>	0	0	3.8	0	0
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	1,339	1,064	4,055.0	537	3,352
<i>Elymus glaucus</i> ssp. <i>glaucus</i>	0	0	0	47	47
<i>Eremogone pumicola</i>	0	0	0	8	8
<i>Ericameria greenei</i>	0	0	875.2	95	237
<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	0	2,566.5	214	555
<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	0	71.7	6	6
<i>Eucephalus ledophyllus</i>	0	0	0	23	23
<i>Holodiscus microphyllus</i> var. <i>glabrescens</i>	0	0	139.4	85	811
<i>Juncus parryi</i>	0	0	9.4	4	4
<i>Lupinus andersonii</i>	0	0	1,665.0	16	169
<i>Lupinus lepidus</i> ssp. <i>lobbii</i>	0	0	0	3	3
<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	0	14.7	0	0
<i>Phlox diffusa</i>	0	0	19.0	1	20
Mixed Species Collection	n/a	n/a	n/a	936	936
TOTAL	3,569	2,780	25,975.5	2,006.9	8,612.4
Central WRD Seed Zone					
<i>Achnatherum occidentale</i>	133	0	1,085.0	25	435
<i>Aconogonon davisiae</i> var. <i>davisiae</i>	95	0	58.0	0.9	0.9
<i>Anemone occidentalis</i>	0	0	3,727.0	0	1,325
<i>Arnica viscosa</i>	0	0	0	0	0.3
<i>Boechera horizontalis</i>	411	84	7.5	0	0
<i>Bromus carinatus</i> var. <i>carinatus</i>	0	0	0	55	55
<i>Carex breweri</i>	0	0	8.0	56	56

Table 9 (continued).

Plant Species	2018 Plants Available Before Planting (#)	Plants Remaining After Planting for 2019 (#)	2018 Seed Available Before Planting (g)	2018 Seed Collection by Park staff (g)	Seed in Storage Available for 2019 (g)
<i>Carex halliana</i>	0	0	1,165.2	0	0
<i>Carex pachycarpa</i>	0	0	0	61	61
<i>Castilleja applegatei</i>	0	0	17.0	5	5
<i>Castilleja</i> species mix	0	0	0	9	9
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	245	0	2,798.2	165	1,765
<i>Ericameria greenei</i>	0	0	128.0	0.9	0.9
<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	0	1,403.6	243	754
<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	0	156.2	62	62
<i>Lupinus lepidus</i> ssp. <i>lobbii</i>	0	0	0	1	1
<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	0	0	211.0	32	53
<i>Phlox diffusa</i>	199	20	28.0	1	1
TOTAL	1,083	104	10,792.7	716.8	4,584.1
North WRD Seed Zone					
<i>Achnatherum occidentale</i>	0	0	704.0	7	7
<i>Aconogonon davisiae</i> var. <i>davisiae</i>	152	0	47.0	59	59
<i>Arnica viscosa</i>	0	0	0.2	0	0
<i>Calyptidium umbellatum</i>	0	0	0	6	6
<i>Carex breweri</i>	726	231	315.0	155	155
<i>Castilleja arachnoidea</i>	0	0	2.5	0	0
<i>Castilleja</i> species mix	0	0	0	22	22
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	484	98	1,220.4	158	158
<i>Eremogone pumicola</i>	0	0	0	3	3
<i>Ericameria greenei</i>	0	0	70.0	0	0
<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	0	4,251.4	17	1,534
<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	236	0	57.9	15	15
<i>Lupinus andersonii</i>	0	0	277.0	59	59
<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	0	301.0	27	27
<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	49	0	128.0	9	9
<i>Phlox diffusa</i>	0	0	28.0	2	7
TOTAL	1,647	329	7,402.4	539	2,061

Table 9 (continued).

Plant Species	2018 Plants Available Before Planting (#)	Plants Remaining After Planting for 2019 (#)	2018 Seed Available Before Planting (g)	2018 Seed Collection by Park staff (g)	Seed in Storage Available for 2019 (g)
NW ERD Seed Zone					
<i>Achnatherum occidentale</i>	74	0	41.2	16	16
<i>Aconogonon davisiae</i> var. <i>davisiae</i>	31	0	93.0	14	34
<i>Bromus carinatus</i> var. <i>carinatus</i>	0	0	374.2	0	0
<i>Calyptridium umbellatum</i>	0	0	0	0.9	0.9
<i>Carex breweri</i>	0	0	53.0	29	29
<i>Castilleja applegateii</i>	0	0	0	3	3
<i>Castilleja arachnoidea</i>	0	0	16.7	0	0
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	766	0	652.3	51	51
<i>Eriogonum marifolium</i> var. <i>marifolium</i>	0	0	156.1	0	0
<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	0	99.0	53	53
<i>Juncus parryi</i>	224	0	191.0	57	57
<i>Luetkea pectinata</i>	91	0	222.0	28	35
<i>Lupinus lepidus</i> var. <i>lobbii</i>	1	0	12.7	29	29
TOTAL	1,187	0	1,911.2	280.9	307.9
NE ERD Seed Zone					
<i>Achnatherum occidentale</i>	0	0	150.6	114	114
<i>Arctostaphylos nevadensis</i>	693	616	0		
<i>Arctostaphylos patula</i>	36	0	0		
<i>Boechera horizontalis</i>	0	0	0		
<i>Bromus carinatus</i> var. <i>carinatus</i>	997	882	252.3	26	26
<i>Calyptridium umbellatum</i>	0	0	0	0.9	0.9
<i>Carex halliana</i>	0	0	712.6	552	1,265
<i>Carex pachycarpa</i>	0	0	0	82	82
<i>Diplacus nanus</i>	0	0	0	3	3
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	597	392	513.2	276	276
<i>Ericameria nauseosa</i> var. <i>speciosa</i>	30	0	66.5	49	49
<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	0	0	83.9		
<i>Lupinus lepidus</i> var. <i>lobbii</i>	0	0	15.0	43	43
<i>Penstemon speciosus</i>	0	0	0	48	48
<i>Phacelia hastata</i> ssp. <i>compacta</i>	0	0	41.4	110	110
TOTAL	2,353	1,890	1,835.5	1,303.9	2,016.9

Site Documentation and Monitoring

Site documentation and monitoring were completed for all sites that were restored in 2016, 2017, and 2018. For sites restored in 2016 and 2017, one- and two-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 and 2017 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 2016/2017 work. However, most sites were assessed as having moderate or good regeneration and were left as-is; they will be reassessed in 2019. For sites restored in 2018, 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. Example of a revegetation site with very good plant establishment after two years. Photo 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 the sites and can be used in combination with the 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 in Botany program files (R:\BOTANY\Ecological Restoration\Rim Drive Rehabilitation project\Revegetation\Site documentation).

Monitoring results showed a clear pattern: restored sites that were protected from further impacts (e.g., contractor damage, trampling) did markedly better than those that experienced additional impacts. Roughly half of the restored sites are doing well and vegetative recovery is progressing with no further action needed. The other half were either damaged by construction impacts, 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 2019 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.

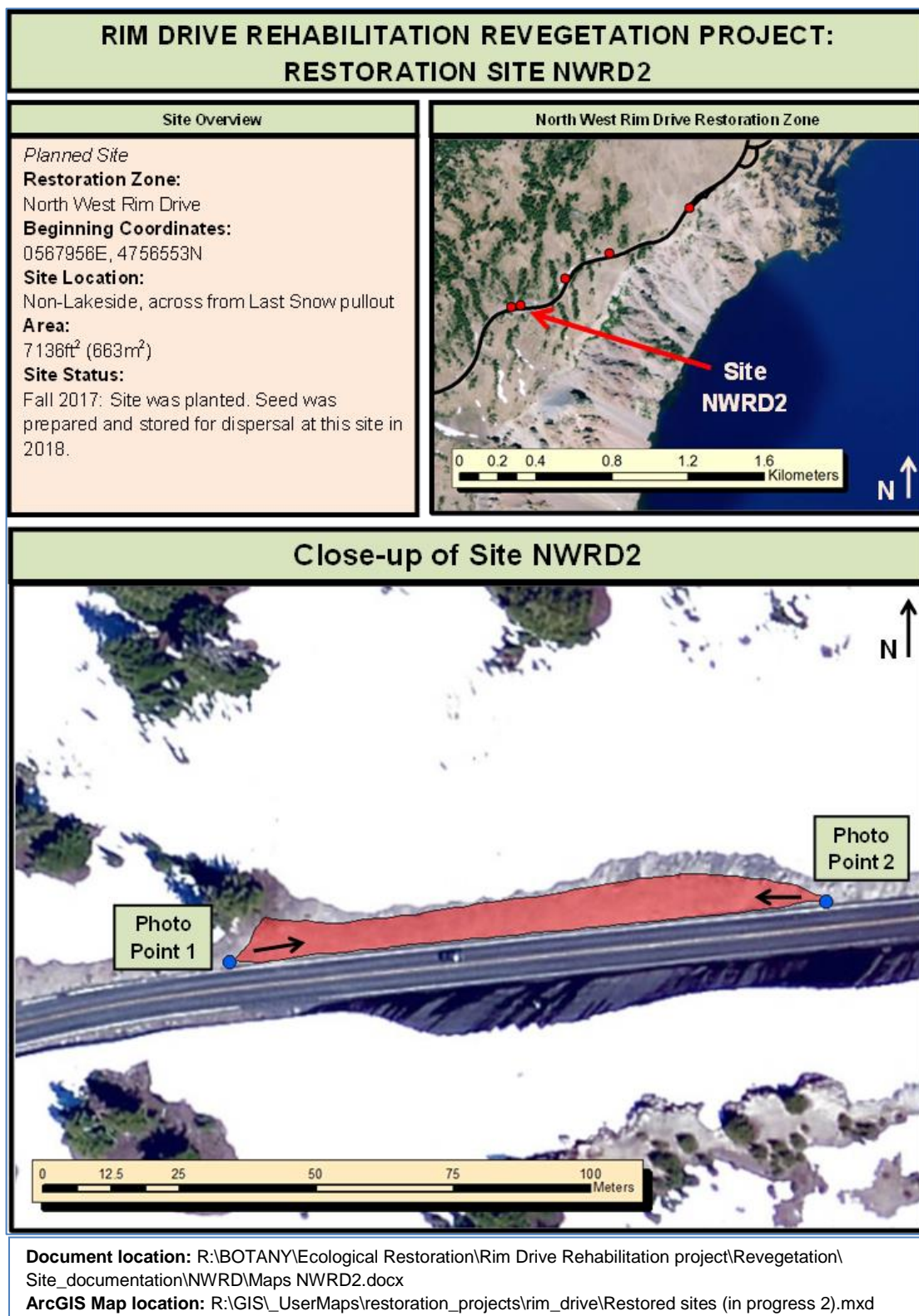


Figure 20. Example of a site overview map that was created in order to aid in site documentation and assist future staff in precisely locating and monitoring restoration sites. Map by Tara Chizinski.



Figure 21. The pinkish hue of the plants in this photo reflects the abundance of spreading groundsmoke at this restoration site. Photo by Tara Chizinski.

Monitoring data also captured the colonization of most restoration sites that were revegetated during 2016-2017 in the North West Rim Drive, Northeast East Rim Drive, and Northwest East Rim Drive seed zones by the native plant spreading groundsmoke (*Gayophytum diffusum*). This species was not recorded during the drafting of restoration prescriptions and is serving the role of a pioneering species into revegetation sites (Figure 21). To date, no other native plant species has appeared at restoration sites that was not present pre-disturbance.

Special Status Plant Management

During the 2018 season, 63 salvaged Crater Lake rockcress plants were replanted at the Skell Head Overlook in the new planting islands and along the outside of the rock wall where they had been salvaged from (Figure 22). Their survival will be tracked over the coming years.



Figure 22. Crater Lake rockcress plants salvaged from the Skell Head overlook (left). Planting of salvaged *Boechera horizontalis* at Skell Head overlook (right). Photos by Carrie Wyler.

Monitoring of other salvaged rare plants is ongoing. At Grotto Cove along East Rim Drive, 30 rare plants were salvaged in June of 2014 before an emergency road stabilization project was implemented. The plants were transplanted back to the site after construction was completed in October 2014. These 30 plants were monitored in 2015, 2016, and 2018, with survival rates of 90%, 57%, and 23%, respectively. Long-term monitoring of salvaging and transplanting rare plants so far shows that this method is only slightly effective at reestablishing rare plant populations, and that any salvage should be augmented with plant propagation and seeding. The best way to maintain rare plant populations remains sparing them from disturbance in the first place.

Invasive Vegetation Management

A total of 14,888 invasive plants were removed from project areas during the 2018 season. Invasive plants were encountered most frequently at Rim Village. Many invasive plant abundances were reduced compared to 2017 and 2016 (Table 10). This may be due to an inability to survey the most heavily impacted areas along West and East Rim Drives for most of the field season due to active construction work. A map of invasive plant locations is displayed in Figure 24.

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 in the meadow by the Crater Lake Lodge has been subject to a large control effort annually since 2013, often using volunteer groups (Figure 23). This site was first treated with herbicide fall 2017 and was treated again in June-July 2018. Sheep sorrel abundance was greatly reduced in 2018, which may be attributable to the effectiveness of chemical



Figure 23. Volunteers assist with manual removal of sheep sorrel in the meadow near the Crater Lake Lodge. Photo by Melody Frederic.

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 plant species planted for revegetation efforts.

Table 10. Abundance (number of plants encountered) of invasive plants within the RDRR project area for 2016, 2017, and 2018.

IVM Region	Invasive Plant Species	2016 Abundance	2017 Abundance	2018 Abundance
Pole Bridge Creek Quarry	Yellow rocket (<i>Barbarea vulgaris</i>)	227	10	9
	St. John's wort (<i>Hypericum perforatum</i>)	2	0	0
	Sand spurry (<i>Spergularia rubra</i>)	6	12	0
	Common dandelion (<i>Taraxacum officinale</i>)	4	9	0
East Rim Drive	Yellow rocket	4	56	2
	Canola (<i>Brassica napus</i>)	1	0	2
	Smooth brome (<i>Bromus inermis</i>)	0	5,157	130
	Cheat grass (<i>Bromus tectorum</i>)	1	1	0
	Common flixweed (<i>Descurainia sophia</i>)	1	0	0
	St. John's wort	49	25	0
	Timothy (<i>Phleum pretense</i>)	2	0	0
	Common plantain (<i>Plantago major</i>)	1	0	0
	Annual bluegrass (<i>Poa annua</i>)	115	40	0
	Common knotweed (<i>Polygonum aviculare</i> ssp. <i>depressum</i>)	5	57	0
	Tansy ragwort (<i>Senecio jacobaea</i>)	0	67	0
	Sand spurry	0	1	0
	Common dandelion	608	368	36
White clover (<i>Trifolium repens</i>)	10	0	0	
West Rim Drive	Common knotweed	10	0	0
	Sheep sorrel	18	0	0
	Sand spurry	1,624	0	0
	Common dandelion	1	0	0
	Timothy grass (<i>Phleum pratense</i>)	0	0	1
Rim Village	Yellow rocket	363	640	98
	Big chickweed (<i>Cerastium fontanum</i> ssp. <i>vulgare</i>)	0	0	1
	Bull thistle (<i>Cirsium vulgare</i>)	1	1	0
	Orchard grass (<i>Dactylis glomerata</i>)	0	2	0
	Broadleaf cottonrose (<i>Filago pyramidata</i> var. <i>pyramidata</i>)	10	0	0
	St. John's wort	1	4	0
	Birdsfoot trefoil (<i>Lotus corniculatus</i>)	0	1	0
	Pineapple weed (<i>Matricaria discoidea</i>)	601	725	719
	English plantain (<i>Plantago lanceolata</i>)	0	3	1
	Common plantain	5	17	0
	Annual bluegrass	0	40	0
	Common knotweed	0	762	305
	Sheep sorrel	14,639	25,998	7,267
	Sand spurry	8,361	16,490	6,142
	Common dandelion	2,188	260	73
	White clover	1,328	535	102
Flannel mullein (<i>Verbascum thapsus</i>)	1	0	0	
	Total	30,187	51,281	14,888

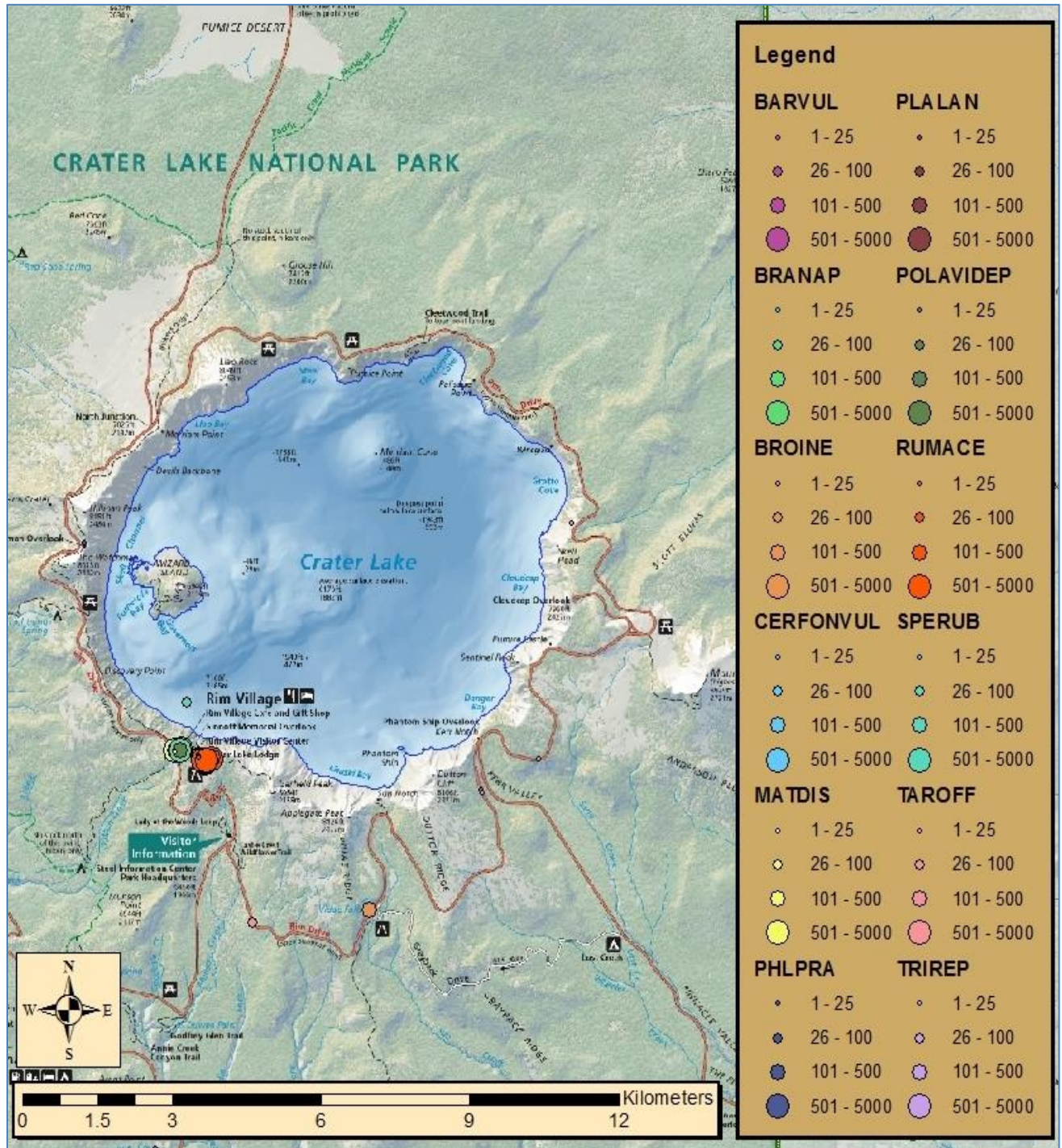


Figure 24. Invasive plant species (number of plants) treated in 2018 in RDRR areas. Species codes: BARVUL = yellow rocket; BRANAP = canola; BROINE = smooth brome; CERFONVUL = big chickweed; MATDIS = pineapple weed; PHLPRA = timothy; PLALAN = English plantain; POLAVIDEP = knotweed; RUMACE = sheep sorrel; SPERUB = sand spurry. Map by Tara Chizinski.

Discussion

The current phase of the Rim Drive Rehabilitation project was scheduled for completion in fall 2017; however, due to the contractor being behind schedule in many locations, the road rehabilitation continued into the fall 2018 field season. The revegetation workload in 2018 was very large, owing to the number of obliterated pullouts and unanticipated areas of disturbance which were scheduled to be ready for revegetation and restoration in 2016/2017 (Appendix A). Not all the sites were completed this season due to lack of time and will need to be prepared, planted, and seeded in the fall of 2019. Monitoring and completing site documentation for areas that underwent restoration work during the 2015—2018 field seasons will aid in evaluating the success of these efforts. These evaluations are vital for tracking efficacy of restoration efforts, identifying areas which need 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 will commence. Phase II will start at Cleetwood Cove and head clockwise along East Rim Drive; the end point is presently undefined. A revegetation plan will be drafted for Phase II as soon as construction plans identify areas of significant disturbance that will require revegetation efforts. Once complete, a new cycle of site documentation, revegetation prescriptions, seed collection, invasive plant survey and control, and rare plant survey will begin in order to minimize impacts of Phase II on the Park's natural resources.

Finishing restoration of sites disturbed in Phase I of the Rim Drive Rehabilitation project will occur concurrently with Phase II planning and preparation in 2019. Many sites still need to be prepared, seeded, and planted in 2019. Additionally, restoration sites that are faring poorly will need to have additional plant materials added. Restoration sites that are recovering poorly due to visitor trampling will need fencing or other barriers to protect fragile vegetation from foot 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. A large plant delivery (7,100 plants) from the Corvallis PMC will be received by the Park in fall 2019 to help wrap up Phase I revegetation efforts. Plant species and quantities to be grown by the Corvallis PMC were chosen based on seed availability; the success and hardiness in the field of individual species after recent experiences with planting; and specific plant species needed for areas yet to be restored.

Recommendations and needs for RDRR work in the 2019 field season include:

- All plants that overwintered in 2018/2019 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/temperature shock. All plants should be checked for moss or liverwort growth, and if present remove so as not to cause disease or rot to the plant. All of these plants should be outplanted in 2019.

- 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, 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, including staging areas and quarries.
- Continue to survey staging areas used by the 2014 Pavement Preservation project, 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 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 2019.
- 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 contractors leaving the disturbed areas completely devoid of vegetation. Much of the grass 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 the coming years for restoration progress and surveyed diligently for invasive plant species.
- The Cleetwood Cove parking lot will need to be planted and seeded in 2019, as construction was not finished by the end of the 2018 season. 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 planting sites. Fencing will be needed so that revegetation sites can be protected from visitor trampling and given time to establish.
- The east embankment at the Cleetwood Cove parking lot needs slope stabilization and erosion control in order 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. This area needs to be reassessed in 2019 to develop a new plan of action.

- Forty pinemat manzanita (*Arctostaphylos nevadensis*) plants were transplanted into one gallon pots with the intention of placing them in the Cleetwood Cove parking lot landscaping islands during the fall of 2019. These were placed in larger pots to increase their size with the hope that trampling impacts would be lessened if vegetation cover was greater. Pinemat manzanita plants that originated from their original, smaller containers (Jumbo 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 in heavily trafficked areas in the future.
- As of fall 2018, the Watchman Overlook landscaping islands were filled in with rocks and loose soil. They were not seeded in 2018 in order to give the soil time to settle into the rocks and crevices over the winter. These landscaping islands may end up needing additional topsoil after the settling is complete. When this area has stabilized it will need to be assessed and seeded.
- Discovery Point Overlook had numerous areas disturbed by road construction and contractors were asked to place boulders in the disturbed areas to prevent these sites from turning into additional parking areas. The boulder placement was not completed until late October 2018, and time did not allow for revegetation. This area will need to be planted and seeded in fall 2019.

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Appendix A – Seed Collection Site Locations

Note: all spatial coordinates are in UTM Zone 10, NAD83 datum.

SOUTH WEST RIM DRIVE		
Munson Meadow (569663E, 4750963N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Boechera howellii</i> • <i>Carex pachycarpa</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Eremogone pumicola</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Lupinus andersonii</i> • <i>Phlox diffusa</i>
Start Meadow (569491E, 4751426N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Bromus carinatus</i> var. <i>carinatus</i> • <i>Carex halliana</i> • <i>Carex pachycarpa</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Elymus glaucus</i> ssp. <i>glaucus</i> • <i>Ericameria greenei</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eucephalus ledophyllus</i> • <i>Lupinus andersonii</i> • <i>Phlox diffusa</i>
Holodiscus Pullout (569253E, 4751604N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Bromus carinatus</i> var. <i>carinatus</i> • <i>Carex halliana</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Ericameria greenei</i> • <i>Holodiscus microphyllus</i> var. <i>glaberscens</i> 	<ul style="list-style-type: none"> • <i>Lupinus andersonii</i> • <i>Phlox diffusa</i>
Discovery Point (568453E, 4752173N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Bromus carinatus</i> var. <i>carinatus</i> • <i>Calyptridium umbellatum</i> • <i>Carex halliana</i> 	<ul style="list-style-type: none"> • <i>Carex pachycarpa</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Ericameria greenei</i> 	<ul style="list-style-type: none"> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> • <i>Holodiscus microphyllus</i> var. <i>glaberscens</i> • <i>Phlox diffusa</i>
Wiz Meadow (567957E, 4752980N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Anaphalis margaritacea</i> • <i>Bromus carinatus</i> var. <i>carinatus</i> • <i>Calyptridium umbellatum</i> 	<ul style="list-style-type: none"> • <i>Carex halliana</i> • <i>Carex pachycarpa</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Ericameria greenei</i> 	<ul style="list-style-type: none"> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> • <i>Lupinus andersonii</i> • <i>Phlox diffusa</i>
Lightning Springs (567731E, 4753860N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Bromus carinatus</i> var. <i>carinatus</i> • <i>Calyptridium umbellatum</i> 	<ul style="list-style-type: none"> • <i>Carex halliana</i> • <i>Carex pachycarpa</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Lupinus andersonii</i> • <i>Phlox diffusa</i>

CENTRAL WEST RIM DRIVE		
Lightning Springs (567731E, 4753860N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Bromus carinatus</i> var. <i>carinatus</i> 	<ul style="list-style-type: none"> • <i>Calyptridium umbellatum</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> 	<ul style="list-style-type: none"> • <i>Lupinus andersonii</i> • <i>Phlox diffusa</i>
Blind Pullout (566958E, 4753456N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Bromus carinatus</i> var. <i>carinatus</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Ericameria greenei</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Phlox diffusa</i>
Union Peak Overlook (566885E, 4754541N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Castilleja applegatei</i> • <i>Castilleja arachnoidea</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Ericameria greenei</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Penstemon davidsonii</i> var. <i>davidsonii</i>
Penstemon Pullout (567202E, 4754971N)		
<ul style="list-style-type: none"> • <i>Penstemon davidsonii</i> var. <i>davidsonii</i> 		
Watchman (567785E, 4755150N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Anemone occidentalis</i> • <i>Castilleja applegatei</i> 	<ul style="list-style-type: none"> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Ericameria greenei</i> 	<ul style="list-style-type: none"> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Phlox diffusa</i>
Diamond Lake Overlook (567389E, 4756062N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Carex breweri</i> • <i>Castilleja applegatei</i> 	<ul style="list-style-type: none"> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Penstemon davidsonii</i> var. <i>davidsonii</i> • <i>Phlox diffusa</i>

NORTH WEST RIM DRIVE		
Diamond Lake Overlook (567389E, 4756062N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Carex breweri</i> • <i>Castilleja applegatei</i> 	<ul style="list-style-type: none"> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> 	<ul style="list-style-type: none"> • <i>Lupinus lepidus</i> var. <i>lobbii</i> • <i>Penstemon davidsonii</i> var. <i>davidsonii</i> • <i>Phlox diffusa</i>
Last Snow (568016E, 4756558N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Carex breweri</i> 	<ul style="list-style-type: none"> • <i>Castilleja applegatei</i> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Lupinus lepidus</i> var. <i>lobbii</i> • <i>Penstemon davidsonii</i> var. <i>davidsonii</i>
Glacier South (568215E, 4756658N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Carex breweri</i> • <i>Castilleja applegatei</i> 	<ul style="list-style-type: none"> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Lupinus lepidus</i> var. <i>lobbii</i> • <i>Phlox diffusa</i>
Glacier North (568505E, 4756850N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Carex breweri</i> • <i>Castilleja applegatei</i> 	<ul style="list-style-type: none"> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Lupinus lepidus</i> var. <i>lobbii</i> • <i>Phlox diffusa</i>
North Junction (569240E, 4757339N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Calyptridium umbellatum</i> • <i>Carex breweri</i> • <i>Castilleja applegatei</i> 	<ul style="list-style-type: none"> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Ericameria greenei</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Lupinus andersonii</i> • <i>Lupinus lepidus</i> var. <i>lobbii</i> • <i>Phlox diffusa</i>

NORTHWEST EAST RIM DRIVE		
North Junction (569240E, 4757339N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Calyptridium umbellatum</i> • <i>Carex breweri</i> 	<ul style="list-style-type: none"> • <i>Castilleja applegatei</i> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> 	<ul style="list-style-type: none"> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Lupinus lepidus</i> var. <i>lobbii</i>
ACODAV Roadside (569862E, 4758457N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Juncus parryi</i>
Llao (570139E, 4758986N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Aconogonon davisiae</i> var. <i>davisiae</i> • <i>Boechera howellii</i> • <i>Carex breweri</i> 	<ul style="list-style-type: none"> • <i>Castilleja applegatei</i> • <i>Castilleja arachnoidea</i> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Eremogone pumicola</i> 	<ul style="list-style-type: none"> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> • <i>Juncus parryi</i> • <i>Lupinus lepidus</i> var. <i>lobbii</i>
Stinky Flats (570364E, 4759151N)		
<ul style="list-style-type: none"> • <i>Calyptridium umbellatum</i> • <i>Eriogonum marifolium</i> var. <i>marifolium</i> 	<ul style="list-style-type: none"> • <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> 	<ul style="list-style-type: none"> • <i>Lupinus lepidus</i> var. <i>lobbii</i>
Luetkea West (570788E, 4759198N)		
<ul style="list-style-type: none"> • <i>Boechera howellii</i> • <i>Juncus parryi</i> 	<ul style="list-style-type: none"> • <i>Luetkea pectinata</i> 	<ul style="list-style-type: none"> • <i>Lupinus lepidus</i> var. <i>lobbii</i>
Luetkea East (571165E, 4759019N)		
<ul style="list-style-type: none"> • <i>Boechera howellii</i> • <i>Carex breweri</i> 	<ul style="list-style-type: none"> • <i>Juncus parryi</i> • <i>Luetkea pectinata</i> 	<ul style="list-style-type: none"> • <i>Lupinus lepidus</i> var. <i>lobbii</i>
Grouse Hill (571945E, 4758953N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> 	
Boundary Pullout (577402E, 4758993N)		
<ul style="list-style-type: none"> • <i>Achnatherum occidentale</i> • <i>Calyptridium umbellatum</i> 	<ul style="list-style-type: none"> • <i>Elymus elymoides</i> ssp. <i>elymoides</i> • <i>Juncus parryi</i> 	<ul style="list-style-type: none"> • <i>Lupinus lepidus</i> var. <i>lobbii</i>

NORTHEAST EAST RIM DRIVE		
Boundary Pullout (577402E, 4758993N)		
• <i>Achnatherum occidentale</i>	• <i>Elymus elymoides</i> ssp. <i>elymoides</i>	• <i>Lupinus lepidus</i> var. <i>lobbii</i>
• <i>Calyptridium umbellatum</i>	• <i>Juncus parryi</i>	
Pumice Point West (573440E, 4758788N)		
• <i>Arctostaphylos nevadensis</i>	• <i>Arctostaphylos patula</i>	
Pumice Point East (573592E, 4758794N)		
• <i>Achnatherum occidentale</i>	• <i>Arctostaphylos patula</i>	• <i>Carex halliana</i>
• <i>Arctostaphylos nevadensis</i>		
Cleatwood West (574287E, 4758867N)		
• <i>Achnatherum occidentale</i>	• <i>Arctostaphylos patula</i>	• <i>Elymus elymoides</i> ssp. <i>elymoides</i>
• <i>Arctostaphylos nevadensis</i>		
Cleatwood East (575061E, 4759098N)		
• <i>Achnatherum occidentale</i>	• <i>Arctostaphylos patula</i>	• <i>Ericameria nauseosa</i> var. <i>speciosa</i>
• <i>Arctostaphylos nevadensis</i>	• <i>Elymus elymoides</i> ssp. <i>elymoides</i>	
Patchy Forest (575947E, 4758497N)		
• <i>Achnatherum occidentale</i>	• <i>Elymus elymoides</i> ssp. <i>elymoides</i>	• <i>Lupinus lepidus</i> var. <i>lobbii</i>
• <i>Bromus carinatus</i> var. <i>carinatus</i>		
West Palisades (575881E, 4757981N)		
• <i>Arctostaphylos nevadensis</i>	• <i>Elymus elymoides</i> ssp. <i>elymoides</i>	• <i>Lupinus lepidus</i> var. <i>lobbii</i>
• <i>Arctostaphylos patula</i>	• <i>Ericameria nauseosa</i> var. <i>speciosa</i>	• <i>Phacelia hastata</i> ssp. <i>compacta</i>
• <i>Bromus carinatus</i> var. <i>carinatus</i>		
Palisades (576324E, 4757676N)		
• <i>Arctostaphylos nevadensis</i>	• <i>Elymus elymoides</i> ssp. <i>elymoides</i>	• <i>Lupinus lepidus</i> var. <i>lobbii</i>
• <i>Arctostaphylos patula</i>	• <i>Ericameria nauseosa</i> var. <i>speciosa</i>	
Wineglass (577330E, 4757108N)		
• <i>Arctostaphylos nevadensis</i>	• <i>Diplacus nanus</i>	• <i>Ericameria nauseosa</i> var. <i>speciosa</i>
• <i>Arctostaphylos patula</i>		
Grotto Cove North (577726E, 4756459N) and Grotto Cove South (577766E, 4756241N)		
• <i>Arctostaphylos nevadensis</i>	• <i>Diplacus nanus</i>	• <i>Lupinus lepidus</i> var. <i>lobbii</i>
• <i>Arctostaphylos patula</i>	• <i>Ericameria nauseosa</i> var. <i>speciosa</i>	
Skell Head Pullout (577601E, 4755494N)		
• <i>Achnatherum occidentale</i>	• <i>Carex halliana</i>	• <i>Lupinus lepidus</i> var. <i>lobbii</i>
• <i>Bromus carinatus</i> var. <i>carinatus</i>	• <i>Elymus elymoides</i> ssp. <i>elymoides</i>	• <i>Phacelia hastata</i> ssp. <i>compacta</i>

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.

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National Park Service
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