



Rim Drive Rehabilitation Revegetation Project

2021 Annual Report





ON THIS PAGE

Collecting showy rabbitbrush (*Ericameria nauseosa* var. *speciosa*) seed on the East side of the Park.
Photo by Carrie Wyler.

ON THE COVER

Collecting shaggy hawkweed (*Hieracium horridum*) seed along East Rim Drive.
Photo by Carrie Wyler.

Rim Drive Rehabilitation Revegetation Project

2021 Annual Report

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Crater Lake, Oregon

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

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

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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 and has been split into phases encompassing iterative work progression. Construction on Phase I of this project has been completed, although revegetation work associated with Phase I continues to be wrapped up. Revegetation work for Phase II commenced in the 2020 season with construction anticipated to start in June 2023. Through developing revegetation prescriptions, 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 2021 field season, 31,268 invasive plants were removed from the project area. Revegetation prescriptions were completed for 29 identified restoration sites for Phase II. Plant materials were collected from five distinct seed zones representing the floral diversity of the Phase II project area. Twenty-six seed accessions were provided to the USFS Dorena Genetic Resource Center for cleaning, and 31 seed accessions were cleaned at the Park. Approximately 240 rare plants were salvaged from within the project area. Documentation was refined for each disturbed site to inform future restoration efforts and assess revegetation efficacy. In 2021, Crater Lake National Park staff outplanted 1,335 native plants, dispersed 6,998 grams of native seed, and monitored 62 revegetated sites throughout areas disturbed by Phase I of the project.

Acknowledgments

The Crater Lake National Park Maintenance staff allowed use of the Ball Diamond and South Yard staging areas for storage of plant materials and related infrastructure. Kirsten Hardin, Helen Oppenheimer, Jennifer Corwin, and Jennifer Longmire assisted with translating construction plans and schedules into tangible restoration goals and timelines. Assistance with seed collection and planting was received from members of the Crater Lake National Park Terrestrial Ecology staff and the Northwest Youth Corps. The Meeker Plant Materials Center maintained fields for seed increase efforts and stored seed. The U.S. Forest Service Dorena Genetic Resource Center aided with seed cleaning and storage.

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.

Phase I of the Rim Drive Rehabilitation project was initiated in 2014 and focused on rockfall mitigation and road rehabilitation along sections of Rim Drive. In 2015 road rehabilitation work affected six miles of West Rim Drive, portions of East Rim Drive (e.g., North Junction to Cleetwood Cove; Skell Head; Grotto Cove), and the Rim Village parking lot. Major construction work on Phase I was completed in November 2018. Several new (i.e., unplanned disturbance) revegetation 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. Despite construction for Phase I being complete at this time, additional revegetation work associated with Phase I continued into the 2021 field season. Phase II will complete the remainder of the Rim Drive Rehabilitation project, starting at Cleetwood Cove and heading clockwise around the rim to Park headquarters. Revegetation work for Phase II commenced in 2020, and construction work is slated to begin during summer 2023. Phase II construction plans have detailed deep patch and edge stabilization areas along the roadway, which allows for better revegetation planning and preparation. In addition to impacting roadways and road shoulders, numerous pullouts, parking areas, and parking lots have been and will be modified. These modifications include obliterating unofficial pullouts (Figure 1), shrinking the footprint of excessively large parking areas (Figure 1), and installing landscaping islands in high visitor use areas. A master list of planned revegetation sites for Phase II of the project is provided in Appendix A, and a map of site locations is displayed in Figure 2.

Additionally, road work has and will affect numerous rare and/or sensitive plant species within the project area. 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 and revegetation plans 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.

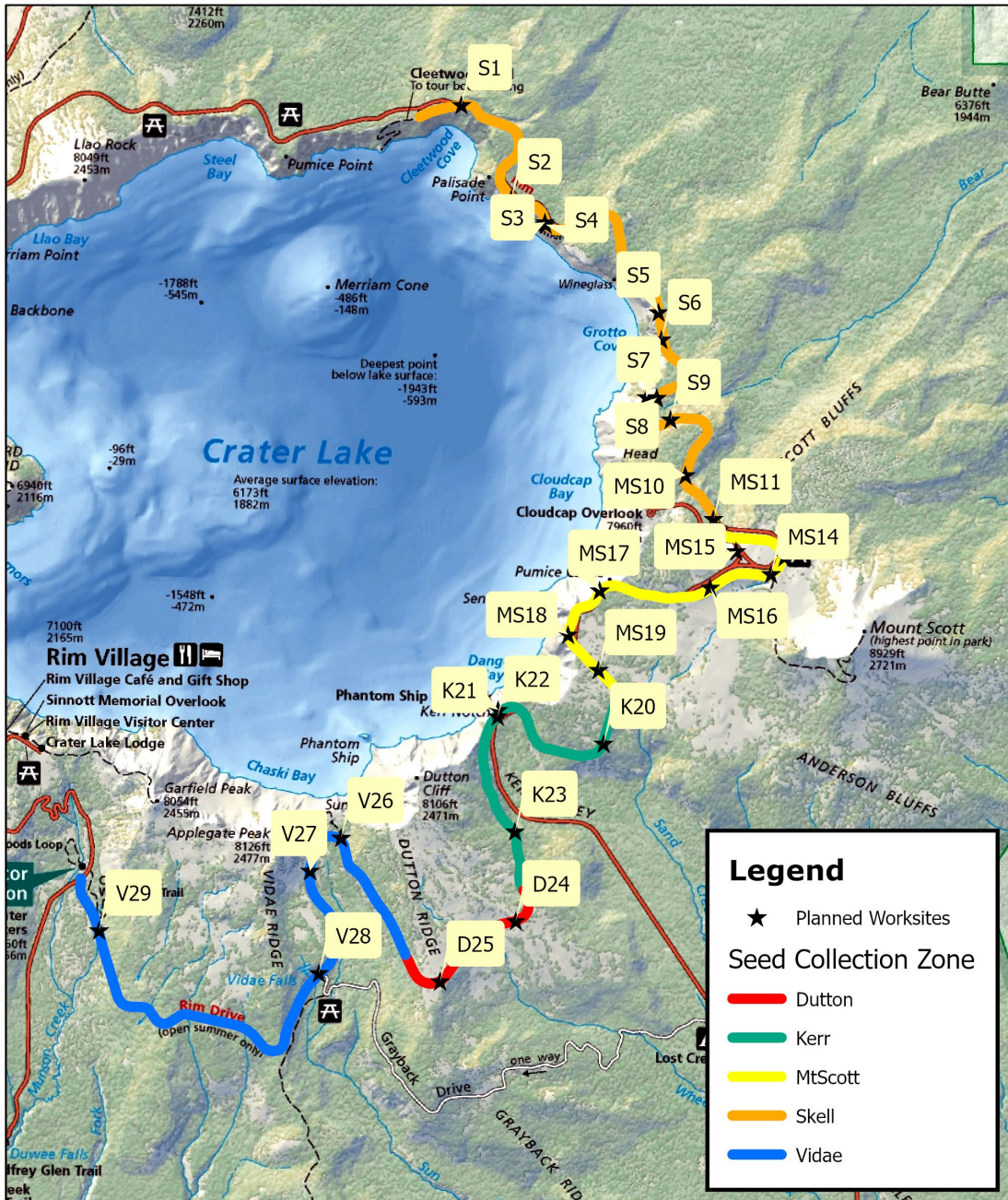


Figure 1. Top: Example of an excessively wide pullout within the project area. Photo by Jen Hooke. Bottom: User-created pullouts before (left; photo by Carrie Wyler) and after (right; photo by Scott Heisler) obliteration as part of the Rim Drive Rehabilitation project.

Crater Lake National Park

RDRR Phase 2 - Planned Worksites

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Figure 2. Map of planned revegetation sites by seed zone for Phase II of the RDRR project. Sites M12 and M13 are near sites M11 and M14, respectively. Map by Scott Heisler.

Restoration of areas disturbed by the Rim Drive Rehabilitation project (Figure 3) is necessary to jumpstart natural succession of vegetation communities, protect the rim environment from soil erosion, and prevent 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. 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.



Figure 3. Conducting restoration outplantings (left) and collecting seed (right) for the Rim Drive Rehabilitation project. Photos by Carrie Wyler.

The 2021 field season focused on documenting restoration site prescriptions, refining a revegetation plan, monitoring completed restoration sites, gathering plant materials, and nursery plant care. Five seasonal Biological Science Technicians (Plants) were partially funded by the RDRR project in 2021; season length was from May 24 – September 30.

Methods

Efforts made by the Botany program in 2021 can be organized into three components: (1) revegetation; (2) special status plant management; and (3) invasive vegetation management; these are described below.

Revegetation

Site Prescriptions

Prior to construction, revegetation prescriptions were developed for each area slated for restoration. These prescriptions serve to document the pre-disturbance site features and plant community 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. This

documentation was established to inform revegetation efforts by providing a baseline from which to determine the quantities of plants and seed to be used at each site. Sometimes unanticipated disturbance results from construction; in these instances, *ex post facto* restoration prescriptions are developed from adjacent undisturbed plant communities and the restoration is deemed an “unplanned” site. For 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 (Wyler and Hooke 2022). Revegetation prescriptions and the revegetation plan are housed on the Botany file server at Park headquarters.

Seed Collection

The Phase II RDRR 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 2) were defined for Phase II of the project based on the same Phase I parameters and named for prominent features in those areas:

- Skell
- Mt. Scott
- Kerr
- Dutton
- Vidae

Once seed zones were delineated, a discrete revegetation species list was developed for the project. To develop cost-effective agreements and work plans between CRLA and the partners with responsibility for seed cleaning, seed storage, and plant propagation for this project, it has been found that using eight to ten plant species (accessions) per seed zone is adequate for revegetation efforts. Species substitutions and species additions are made as necessary to help fill any gaps in the species accession list. The U.S. Forest Service Dorena Genetic Resource Center (DGRC) is assisting CRLA with seed cleaning and plant propagation for Phase II of the RDRR project.

Since the inception of Phase I of the RDRR project, CRLA has developed the capacity to clean and propagate a limited selection of plant species in-house. While maintaining eight to ten accessions per seed zone is still abided by when dealing with Park plant materials partners, additional plant species have been included for Phase II seed zones that will be cleaned and propagated at the Botany program’s native plant nursery at the Ball Diamond staging area at Park headquarters. The core eight to ten accession species are designated as “priority” seed collection species (Table 1).

Denver Service Center (DSC) revegetation staff recommends collecting large quantities of seed from abundantly occurring species, as custom seed mixes can be supplemented with excess seed that can also be used to revegetate unanticipated disturbance areas. As per the “Seed Collection in National Parks” manual (Taliga et al. 2015), seed is collected ideally from 30 - 100 individual plants per population, taking care not to collect more than 20% of seed from the total population unless it is slated for removal due to construction, in which case as much seed as possible should be collected.

During the 2021 field season, no seed was collected for Phase I. Seed collection for Phase II began in 2020 and continued in 2021 (Table 1).

Table 1. Phase II RDRR seed collection list per seed collection zone.

SEED ZONE	PLANT TAXA (Scientific name, common name)	
Skell	<i>Eriocoma occidentalis</i> * --western needlegrass <i>Calyptidium umbellatum</i> * --pussypaws <i>Carex pachycarpa</i> * --many-rib sedge <i>Ceanothus prostratus</i> var. <i>prostratus</i> --Mahala mat <i>Diplacus nanus</i> --dwarf monkeyflower <i>Ericameria nauseosa</i> var. <i>speciosa</i> * --showy rabbitbrush <i>Eriogonum nudum</i> var. <i>nudum</i> --barestem buckwheat <i>Eriogonum ovalifolium</i> var. <i>nivale</i> --cushion buckwheat <i>Holodiscus microphyllus</i> var. <i>glabrescens</i> * --bush ocean spray	<i>Ipomopsis congesta</i> ssp. <i>montana</i> --palm leaf ballhead gilia <i>Juncus parryi</i> * --Parry's rush <i>Linanthus pungens</i> --granite gilia <i>Lupinus lepidus</i> var. <i>lobbii</i> * --prostrate lupine <i>Oxyria digyna</i> --mountain sorrel <i>Packera cana</i> --wooly groundsel <i>Penstemon speciosus</i> --royal penstemon <i>Phacelia mutabilis</i> * --changeable phacelia <i>Purshia tridentata</i> --antelope brush
Mt. Scott	<i>Aconogonon davisiae</i> var. <i>davisiae</i> * --Davis' knotweed <i>Alnus alnobetula</i> ssp. <i>sinuata</i> --Sitka alder <i>Boechera howellii</i> --Howell's flatseed rockcress <i>Calyptidium umbellatum</i> * --pussypaws <i>Carex pachycarpa</i> * --many-rib sedge <i>Castilleja arachnoidea</i> --cobwebby paintbrush <i>Dieteria canescens</i> var. <i>shastensis</i> --rayless Shasta aster <i>Ericameria greenei</i> * --Greene's goldenbush <i>Eriocoma occidentalis</i> * --western needlegrass <i>Eriogonum marifolium</i> var. <i>marifolium</i> * --Sierra eriogonum	<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> --alpine buckwheat <i>Eucephalus ledophyllus</i> --Cascade aster <i>Hulsea nana</i> --dwarf hulsea <i>Juncus parryi</i> * --Parry's rush <i>Lomatium martindalei</i> --Cascade desert parsley <i>Lupinus lepidus</i> var. <i>lobbii</i> * --prostrate lupine <i>Penstemon davidsonii</i> var. <i>davidsonii</i> --Davidson's penstemon <i>Phacelia mutabilis</i> * --changeable phacelia <i>Raillardella argentea</i> --silky raillardella
Kerr	<i>Ageratina occidentalis</i> --western boneset <i>Alnus alnobetula</i> ssp. <i>sinuata</i> --Sitka alder <i>Arnica cordifolia</i> --heart-leaved arnica <i>Arnica longifolia</i> --longleaf arnica <i>Calyptidium umbellatum</i> * --pussypaws <i>Carex</i> species* <i>Drymocallis glandulosa</i> * --sticky cinquefoil <i>Elymus glaucus</i> ssp. <i>glaucus</i> --blue wildrye <i>Ericameria greenei</i> * --Greene's goldenbush <i>Erigeron glacialis</i> var. <i>glacialis</i> --peregrine fleabane	<i>Eriogonum marifolium</i> var. <i>marifolium</i> * --Sierra eriogonum <i>Eriogonum nudum</i> var. <i>nudum</i> --barestem buckwheat <i>Hackelia micrantha</i> -- blue stickseed <i>Holodiscus microphyllus</i> var. <i>glabrescens</i> * --bush ocean spray <i>Juncus parryi</i> * --Parry's rush <i>Lomatium martindalei</i> --Cascade desert parsley <i>Lupinus lepidus</i> var. <i>lobbii</i> * --prostrate lupine <i>Penstemon rupicola</i> --cliff penstemon <i>Phacelia mutabilis</i> * --changeable phacelia <i>Raillardella argentea</i> --silky raillardella

SEED ZONE	PLANT TAXA (Scientific name, common name)	
		<i>Ribes erythrocarpum</i> -- Crater Lake currant <i>Ribes lacustre</i> --swamp currant <i>Eriocoma occidentalis</i> * --western needlegrass
Dutton	<i>Aconogonon davisiae</i> var. <i>davisiae</i> * --Davis' knotweed <i>Anemone occidentalis</i> --western pasqueflower <i>Calyptridium umbellatum</i> * --pussypaws <i>Castilleja arachnoidea</i> --cobwebby paintbrush <i>Chaenactis alpina</i> --alpine chaenactis <i>Dieteria canescens</i> var. <i>shastensis</i> --rayless Shasta aster <i>Ericameria greenei</i> * --Greene's goldenbush <i>Eriocoma occidentalis</i> * --western needlegrass	<i>Eriogonum marifolium</i> var. <i>marifolium</i> * --Sierra eriogonum <i>Eriogonum nudum</i> var. <i>nudum</i> --barestem buckwheat <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> --alpine buckwheat <i>Eucephalus ledophyllus</i> --Cascade aster <i>Juncus parryi</i> * -- Parry's rush <i>Lupinus lepidus</i> var. <i>lobbii</i> * --prostrate lupine <i>Phacelia mutabilis</i> * --changeable phacelia <i>Raillardella argentea</i> --silky raillardella
Vidae	<i>Aconogonon davisiae</i> var. <i>davisiae</i> * --Davis' knotweed <i>Anemone occidentalis</i> --western pasqueflower <i>Calyptridium umbellatum</i> * --pussypaws <i>Carex halliana</i> --Hall's sedge <i>Carex pachycarpa</i> * --many-rib sedge <i>Castilleja arachnoidea</i> --cobwebby paintbrush <i>Elymus glaucus</i> ssp. <i>glaucus</i> --blue wildrye <i>Ericameria greenei</i> * --Greene's goldenbush <i>Eriocoma occidentalis</i> * --western needlegrass <i>Erigeron glacialis</i> var. <i>glacialis</i> --peregrine fleabane	<i>Eriogonum marifolium</i> var. <i>marifolium</i> * --Sierra eriogonum <i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i> --alpine buckwheat <i>Erythranthe lewisii</i> --great purple monkeyflower <i>Holodiscus microphyllus</i> var. <i>glabrescens</i> * -- bush ocean spray <i>Juncus parryi</i> * -- Parry's rush <i>Lupinus albicaulis</i> var. <i>shastensis</i> --pine lupine <i>Lupinus lepidus</i> var. <i>lobbii</i> * --prostrate lupine <i>Penstemon davidsonii</i> var. <i>davidsonii</i> -- Davidson's penstemon <i>Phacelia mutabilis</i> * --changeable phacelia <i>Senecio triangularis</i> --arrowleaf groundsel

* = Denotes priority seed collection species.

Shaded plant species were not collected in 2021, but may be targeted for collection in the future.

The seed collection process commenced in 2021 by observing and documenting the phenology of each priority collection species at each revegetation site within each seed zone within the Phase II project area. Notes were taken on plant phenology, seed maturity, and seed collection techniques; these observations helped refine seed collection protocols (Beck et al. 2017). A map was developed for all seed collection locations in each seed zone (Figure 2).

When seeds were mature, they were collected, dried, and stored until shipment to the DGRC. Within each zone a single bag was used to collect all the seed from an individual species (Figure 4). In the field, bags were labelled with species code, collection date, and seed zone. After collection, seeds were transported to the seed drying and storage facility in the Stall Nine garage at Park headquarters (Figure 4). When seeds arrived at this facility, records were kept for each species with collection

dates, specific collection location, and seed zone. Seeds were then placed inside 30-gallon plastic storage totes secured with window screen at the top, allowing ventilation while reducing chances of predation. Plant species with very small seeds were first placed in smaller plastic bins before being stored within the larger 30-gallon tubs (Figure 4). 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 to speed the drying process.

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



Figure 4. Seed drying and storage facility at Park headquarters (left). Collected seed before cleaning (middle). Seed drying in a container inside a drying bin with ventilated lid (right). Photos by Carrie Wyler.

Some species were not collected from in 2021 due to the project timeline being delayed. At the time of this writing, construction is planned to progress in discrete segments that will be completed prior to beginning work in a new area. In Phase I of the project, construction work occurred in several areas simultaneously with the revegetation work pushed toward the end of the project’s duration. This iterative progression of Phase II of the project will make it easier to complete restoration at the end of each construction season instead of completing all the restoration for the project in a more condensed timeframe, making the project more manageable.

Plant Care and Nursery Work

Anticipating the need for established containerized plants for use in Phase II and the slow growth of native plants in the high elevation conditions at CRLA, an advance round of plant propagation was conducted at CRLA in fall 2020 and 2021. Approximately 130 plants were propagated in 2021 and are being overwintered at the Ball Diamond nursery at Park headquarters. These plants will require care and maintenance throughout future field seasons. Once the snow melts in June, plants are covered with a shade house (40’ x 20’ x 10’ – Figure 5).

A method of plant propagation previously established by the Botany program was utilized to address staffing and equipment limitations (Heisler et al. 2019). This method uses the snowpack at CRLA

for cold stratification of pre-seeded pots. Selection of plant species and quantities for this effort were based upon the program’s familiarity with the project area and experience gained from Phase I of the project. Additional difficult-to-propagate plant material needs for this project will be sourced through an interagency agreement with the DGRC.



Figure 5. Overwintered plants under snow (top). Shadehouse at the Ball Diamond (bottom). Photos by Carrie Wyler.

When ambient temperature dropped below freezing the containers were consolidated and mulch was stacked around the perimeter of consolidated containers to prevent root freezing (Figure 6). These plants will need further care in the summer of 2022 including watering, fertilization, and transplanting into larger containers.



Figure 6. Distributing mulch around the edges of pots to insulate against frigid winter temperatures (left). Consolidated plants at the Park's Ball Diamond prior to overwintering (right). Photos by Carrie Wyler.

Site Documentation and Monitoring

The restoration process for each site was documented using monitoring forms and photo points. Sites restored prior to 2021 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 2021, data were recorded on the number of plants outplanted by species, 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 to document the appearance of the site post-disturbance relative to pre-disturbance. For unplanned sites, new photo points were developed, and photos were taken prior to planting. Repeat photo points are taken and sites are monitored at one, three, and five years post-revegetation in order to monitor the status of vegetation recovery. Data are maintained for each restoration site including the site prescription, photo points, and monitoring forms. These files are kept in site documentation binders in the Botany office and are also located on the Botany file server.

Special Status Plant Management

In the process of rehabilitating Rim Drive and implementing rockfall mitigation, many special status plant populations growing adjacent to Rim Drive have been or will be impacted. This includes populations of rare and sensitive plants such as Shasta arnica (*Arnica viscosa*), pumice moonwort (*Botrychium pumicola*), Crater Lake rockcress, a currently undescribed species of rockcress (*Boechera* undescribed), shaggy hawkweed (*Hieracium horridum*), and whitebark pine (*Pinus albicaulis*). Phase I construction displaced populations of the Crater Lake rockcress and Shasta arnica (Figure 7). All these species are present in higher numbers in the Phase II project area and impacts are expected.



Figure 7. Crater Lake rockcress (left) and Shasta arnica (right). Photos by Jen Hooke.

Due to the high probability of this project to disturb or eliminate plants in the road prism it was decided to salvage as many rare plant species that may be affected as practical. Plants were excavated with hand trowels and transplanted into pots using local soil to maintain local soil biological associations and soil composition (Figure 8). Plants were then transported to the Park’s native plant nursery at the Ball Diamond, where they were placed in a shadehouse. These plants will need to be cared for until they can be returned to their original locations where they will be planted just beyond the zone of regular roadside maintenance.



Figure 8. Salvaging Crater Lake rockcress from East Rim Drive roadside (left). Carefully transplanting roadside pumice moonwort into pots from projected disturbance areas (right). Photos by Carrie Wyler.

Five-needle pine species (Figure 9) are declining throughout their ranges due to their susceptibility to the disease white pine blister rust, caused by the non-native fungal pathogen *Cronartium ribicola* among other factors. Two five-needle pine species occur within the road prism of the project area: whitebark pine (*Pinus albicaulis*) and western white pine (*Pinus monticola*). The U.S. Fish and Wildlife Service has proposed listing whitebark pine as a threatened species under the Endangered Species Act; western white pine is a CRLA species of management concern. To better protect these iconic trees against impacts from construction activities, a survey of five needle pine species was conducted in 2020 in areas where high levels of roadside disturbance were anticipated. This survey provided precise locations of these species for incorporation into project plans and serves as a monitoring reference for the CRLA Botany program.



Figure 9. Whitebark pine (left) and western white pine (right). Photos by Jen Hooke.

To mitigate impacts to the Park’s special status plant species, baseline information is collected on pre-disturbance plant populations and seed is collected from rare plants for future propagation and revegetation efforts. Rare plant populations are mapped, and census data collected for each population. Wherever possible, special status plant species are protected from construction impacts. When impacts are unavoidable, rare plants are salvaged as feasible, cared for at a holdover facility, and transplanted back into their habitat post-disturbance. Additionally, supplemental planting of propagated rare plants is conducted, and reestablished populations are monitored to inform management. Extensive portions of East Rim Drive will be impacted by deep patch and edge stabilization work. These areas were surveyed for rare plants, and those encountered were documented with a submeter GNSS receiver using real-time SBAS correction (EOS Arrow 100).

Invasive Vegetation Management

Crater Lake National Park has assigned all its 92 non-native plant species a management priority of Low, Medium, High, or Watch. All high priority species are actively targeted for control efforts; medium priority species are targeted as time and resources allow. Low priority species are usually not targeted for management, either because populations of these species are not aggressively spreading, or populations are beyond control. Watch species are those that have been documented within the Park but have not been observed in some time (> 10 years) and are believed to be eradicated from within Park boundaries. If any watch species are found within the Park, they receive a management priority of high. These priorities may change depending upon situation and location. For example, most of the Rim Drive environment is relatively pristine and lacking non-native plant members. In this case, medium or low priority species may be treated in this area to protect the integrity of the vegetation communities adjacent to Rim Drive. Additionally, many rare and/or sensitive 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 low abundances of 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 2021, most of the project area was surveyed for non-native, invasive plant species (Figure 10). Roadsides were surveyed throughout the season by foot. Project staging areas (Roundtop Quarry, the Ball Diamond, Pole Bridge Creek Quarry, and the junction of East Rim Drive and Pinnacles Road) were surveyed at least once by foot in their entirety, including access roads and around piles of materials.

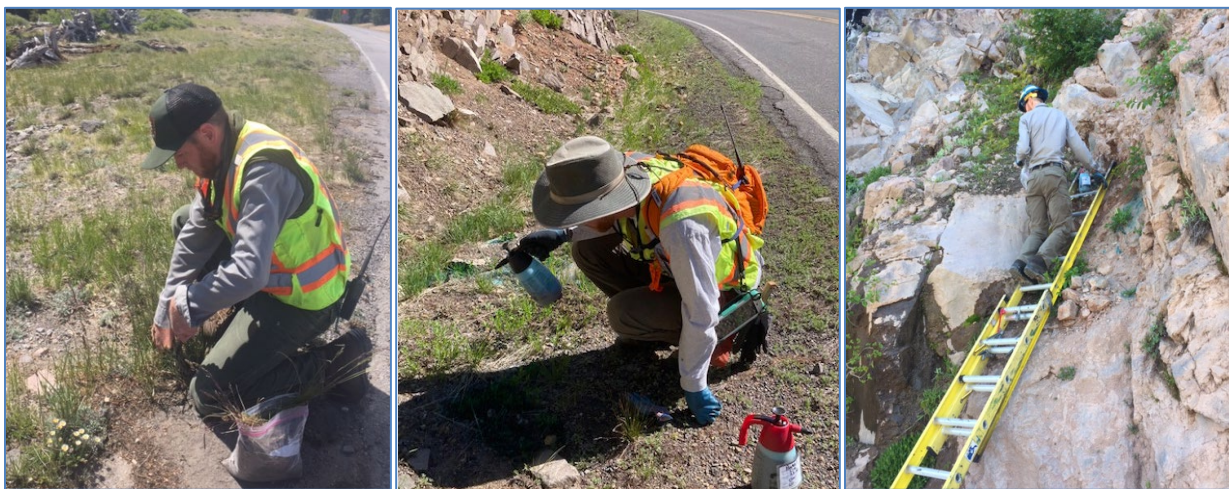


Figure 10. Manually controlling an invasive grass near Skell Head overlook (left). Chemically controlling sheep sorrel (*Rumex acetosella*) on East Rim Drive (middle). Chemically treating common dandelion (*Taraxacum officinale*) on a cliffside along East Rim Drive (right). Photos by Carrie Wyler.

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 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.

Results

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

Revegetation

Site Prescriptions

As of November 2021, 62 restoration sites have been defined for Phase I and 29 restoration sites for Phase II of the RDRR project, each with a unique revegetation prescription based on pre-disturbance conditions (Table 2). Identification of Phase II restoration sites was guided by construction plan sets (95% design phase) and did not include disturbed sites at Roundtop Quarry or areas affected by deep patch or edge stabilization treatments. It is likely the number of sites will increase as impacts from those treatments become more apparent. When Phase I of the Rim Drive Rehabilitation project was completed, the actual area disturbed was found to be greater than three times what was planned (Wyler et al. 2020). The planned area of disturbance for Phase II of this project is anticipated to affect 21.2 acres. Full details of each site's prescription and planned versus actual disturbance areas can be found on the Botany file server. Similar documentation will be made for Phase II of the project to track disturbed areas (Figure 11).



Figure 11. User-created pullout (restoration site SWRD1) before (left) and after (right) rehabilitation and revegetation efforts. Photos by Carrie Wyler.

Table 2. Example of a site documentation form for the RDRR project.

Seed Zone: Dutton		ID: D17	Planned site
Location: Dutton Ridge, WBP tree pullout, non-lake side, (station 644+ to 646+)			
Site Description: gravel pullout to obliterate			
Pre-Disturbance Site Information			
Plant Species	Common Name	Relative % Cover	
<i>Aconogonon davisiae</i> var. <i>davisiae</i>	Newberry's fleecflower	5	
<i>Agoseris</i> sp.	Agoseris	2	
<i>Calyptridium umbellatum</i>	Pussypaws	3	
<i>Carex halliana</i>	Hall's sedge	33	
<i>Castilleja arachnoidea</i>	Cobwebby paintbrush	3	
<i>Ericameria greenei</i>	Greene's goldenbush	15	
<i>Eriogonum marifolium</i> var. <i>marifolium</i>	Sierra eriogonum	10	
Grasses (<i>Elymus elymoides</i> ssp. <i>elymoides</i> , <i>Eriocoma occidentalis</i>)	Common squirreltail, western needlegrass	15	
<i>Lupinus albicaulis</i> var. <i>shastensis</i>	Pine lupine	2	
<i>Lupinus lepidus</i> var. <i>lobbii</i>	Prostrate lupine	5	
<i>Phacelia hastata</i> var. <i>compacta</i>	Compact phacelia	3	
<i>Viola purpurea</i>	Goosefoot violet	2	
Other		2	
	Total Cover:	100%	
Associated species: <i>Raillardella agenta</i> (silky raillardella), <i>Pinus albicaulis</i> (whitebark pine -- sensitive)			
UTM (Zone 10, NAD 83):	End: 0576025	End: 4749089	
Total Vegetative Cover: 65%		Elevation: 7,204 ft.	
Slope: low (-8 degrees)	Aspect: NW	Snowmelt out:	
Soil "hardness," presence of rocks:			
General Soil description: pumice, sand, gravel 6: sand, gravelly			
Ameliorating microsite features: duff, conifer needles, small diameter branches, gravel, 1: existing vegetation 5: fine organic debris			
Wind exposure: high	Canopy cover (overall): low-medium		
Area:			
Comments: Whitebark pine clump at site			
Recorder: CW, SH		Date: 7/8/20	

Seed Collection

Plant phenology was monitored during the field season through biweekly visits to collection sites, and then later in the season concurrently with seed collection. In 2021, seed collection for Phase II of the project commenced in early August and continued into early October. The peak seed collection for the bulk of plant species in most of the seed zones occurred from mid-August to mid-September (Table 3). Some plant species offered a long collection period due to multiple flowering episodes throughout the growing season. The 2021 growing season was notable for extreme drought conditions and the hottest summer on record as recorded by the servicing National Weather Service office (Sandler 2021), including a severe heat wave in mid-June. The effect of these biotic stresses in the project area was readily visible in plant growth rates and seed production quantities.

Table 3. 2021 seed collection periods for priority collection species indicated by gray shading.

Species	JULY (late) July (mid)	AUG (early) AUG (mid) AUG (late)	SEPT (early) SEPT (mid) SEPT (late)	OCT (early) OCT (mid) OCT (late)
<i>Eriocoma occidentale</i>				
<i>Aconogonon davisiae</i> var. <i>davisiae</i>				
<i>Calyptridium umbellatum</i>				
<i>Carex pachycarpa</i>				
<i>Drymocallis glandulosa</i>				
<i>Ericameria greenei</i>				
<i>Ericameria nauseosa</i> var. <i>speciosa</i>				
<i>Eriogonum marifolium</i> var. <i>marifolium</i>				
<i>Holodiscus microphyllus</i> var. <i>glabrescens</i>				
<i>Juncus parryi</i>				
<i>Lupinus lepidus</i> var. <i>lobbii</i> *				
<i>Penstemon</i> species				
<i>Phacelia hastata</i> var. <i>compacta</i>				

*Species with two flowering and seed production episodes in one season.

In 2021, Botany staff collected seed from species on the Phase II RDRR project's species collection list; quantities are listed in Table 4. Grasses and sedges produced abundant seed that was easy to collect, and thus made up the bulk of the 2021 seed collection. Species that were collected in lower quantities include lupine (*Lupinus* sp.), pussypaws (*Calyptridium umbellatum*), and Greene's goldenbush (*Ericameria greenei*) as predation from unknown insects and mammals significantly reduced the quantity and quality of available seed. However, these species do extremely well at establishing in disturbed areas from seed, and therefore are worth the extra effort to collect. Davis' knotweed (*Aconogonon davisiae* var. *davisiae*) continued to pose a challenge for seed collection and plant propagation efforts by seed. Fertilization appears to be very patchy in the field, and while fruit development can be detected for the first few months after fertilization, many developing seeds appear to be aborted weeks before any viable seed can be acquired. Previous attempts at propagating Davis' knotweed suggest root division/cuttings are viable means of propagation (Trindle and Flessner 2003).

Table 4. Seed collection quantities for 2021.

Seed Zone	Scientific Name	Common Name	Amount collected (grams)
Skell	<i>Boechera horizontalis</i>	Crater Lake rockcress	8.0
	<i>Eriocoma occidentalis</i> *	Western needlegrass	104.3
	<i>Calyptridium umbellatum</i>	Pussypaws	4.2
	<i>Carex pachycarpa</i> *	Many-rib sedge	80.0
	<i>Ceanothus prostratus</i> var. <i>prostratus</i>	Mahala mat	0
	<i>Ericameria nauseosa</i> var. <i>speciosa</i> *	Showy rabbitbrush	34.0
	<i>Eriogonum nudum</i> var. <i>nudum</i>	Barestem buckwheat	3.0
	<i>Hieracium horridum</i>	Shaggy hawkweed	1.0
	<i>Holodiscus microphyllus</i> var. <i>glaberscens</i> *	Bush ocean spray	0
	<i>Juncus parryi</i> *	Parry's rush	22.0
	<i>Lupinus lepidus</i> var. <i>lobbii</i> *	Prostrate lupine	33.7
	<i>Oxyria digyna</i>	Mountain sorrel	5.0
	<i>Penstemon speciosus</i>	Royal penstemon	49.0
	<i>Phacelia mutabilis</i> *	Changeable phacelia	5.9
Mt. Scott	<i>Eriocoma occidentalis</i> *	Western needlegrass	76.2
	<i>Aconogonon davisiae</i> var. <i>davisiae</i> *	Davis' knotweed	37.5
	<i>Boechera</i> undescribed	Undescribed rockcress	1.0
	<i>Calyptridium umbellatum</i>	Pussypaws	3.0
	<i>Carex pachycarpa</i>	Many-rib sedge	78.2
	<i>Castilleja arachnoidea</i>	Cobwebby paintbrush	0
	<i>Dieteria canescens</i> var. <i>shastensis</i>	Rayless Shasta aster	2.0
	<i>Ericameria greenei</i> *	Greene's goldenbush	33.0
	<i>Eriogonum marifolium</i> var. <i>marifolium</i> *	Sierra eriogonum	61.4
	<i>Eriogonum pyrolifolium</i> var. <i>coryphaeum</i>	Alpine buckwheat	37.0
	<i>Hieracium horridum</i>	Shaggy hawkweed	5.0
	<i>Hulsea nana</i>	Dwarf Hulsea	13.0
	<i>Juncus parryi</i> *	Parry's rush	26.4
	<i>Lomatium martindalei</i>	Cascade desert parsley	5.0

Seed Zone	Scientific Name	Common Name	Amount collected (grams)
	<i>Lupinus lepidus</i> var. <i>lobbii</i> *	Prostrate lupine	89.2
	<i>Phacelia mutabilis</i> *	Changeable phacelia	6.3
	<i>Raillardella argentea</i>	Silky raillardella	7.0
Kerr	<i>Eriocoma occidentalis</i> *	Western needlegrass	1.0
	<i>Arnica longifolia</i>	Longleaf arnica	3.0
	<i>Boechera howellii</i>	Howell's flatseed rockcress	1.0
	<i>Carex species</i> *	Sedge species	22.0
	<i>Drymocallis glandulosa</i> *	Sticky cinquefoil	43.4
	<i>Elymus glaucus</i> ssp. <i>glaucus</i>	Blue wildrye	38.5
	<i>Eriogonum nudum</i> var. <i>nudum</i>	Barestem buckwheat	11.0
	<i>Hackelia micrantha</i>	Blue stickseed	4.0
	<i>Lomatium martindalei</i>	Cascade desert parsley	2.0
	<i>Phacelia mutabilis</i> *	Changeable phacelia	1.2
	<i>Raillardella argentea</i>	Silky raillardella	1.0
	<i>Ribes erythrocarpum</i>	Crater Lake currant	13.0
	<i>Ribes lacustre</i>	Swamp currant	1.0
Dutton	<i>Eriocoma occidentalis</i> *	Western needlegrass	10.0
	<i>Aconogonon davisiae</i> var. <i>davisiae</i> *	Davis' knotweed	13.4
	<i>Castilleja arachnoidea</i>	Cobwebby paintbrush	7.0
	<i>Chaenactis alpina</i>	Alpine chaenactis	4.8
	<i>Ericameria greenei</i> *	Greene's goldenbush	1.1
	<i>Eriogonum marifolium</i> var. <i>marifolium</i> *	Sierra eriogonum	181.9
	<i>Eucephalus ledophyllus</i>	Cascade aster	0
	<i>Lupinus lepidus</i> var. <i>lobbii</i> *	Prostrate lupine	13.0
	<i>Phacelia mutabilis</i> *	Changeable phacelia	15.0
	<i>Raillardella argentea</i>	Silky raillardella	0
			4.0
Vidae	<i>Eriocoma occidentalis</i> *	Western needlegrass	15.6
	<i>Arnica viscosa</i>	Shasta arnica	9.0
	<i>Elymus glaucus</i> ssp. <i>glaucus</i>	Blue wildrye	24.0
ALL		TOTAL	1,272.2

*Priority collection species.

To augment the amount of plant materials available for revegetation in both Phase I & II of this project, the seed increase services of the Meeker PMC were utilized. The Meeker PMC maintained two seed increase fields for California brome (*Bromus sitchensis* var. *carinatus*) and common squirreltail (*Elymus elymoides* ssp. *elymoides*) sown from CRLA seed. The 2021 growing season marked the last year of seed production for this effort. Seed production totals are displayed in Table 5.

Table 5. Production totals from seed increase efforts by the Meeker PMC. CBS = clean bulk seed.

Plant Species and Seed Zone	2017 CBS (lbs.)	2018 CBS (lbs.)	2019 CBS (lbs.)	2020 CBS (lbs.)	2021 CBS (lbs.)	Amount CBS (lbs.) Received at CRLA in 2019	Amount CBS (lbs.) Available for Phase II
California brome – West Rim Drive zones	1.6	66.5	157.5	35.0	19.0	0.0	279.6
California brome – East Rim Drive zones	0.2*	8.4	88.5	26.0	10.6	8.6	125.1
Squirreltail – all zones	9.6	123.5	218.5	21.0	53.0	20	404.6

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

Plant Care and Nursery Work

After the snow melted in 2021, plants that had been overwintered were assessed and inventoried. Plants without any green growth or with rotted roots were discarded. Plants with well-developed roots were transplanted into larger containers while others with detritus, moss, liverwort, or volunteer plants were cleaned (Figure 12).

Most of the grass species in the nursery became infected with a rust in the fall of 2020 and 2021. The infected areas were trimmed and treated with a baking soda, soap, oil, and water mixture in 2020. This helped reduce the rust infestation but not eliminate it. In 2021, infected plants were treated with a sulfur water mixture. This helped to reduce but not eliminate the infestation. Plants that were still infected with rust in August 2021 were disposed of in the Park's trash compactor. Disposing of the infected plants was necessary to eradicate the rust infestation. All nursery plants will need to be assessed in 2022.

Detailed reports of daily nursery activities are on file in the Botany office in the Nursery Activities binder. Over the fall and winter of 2020-2021 1,134 plants were propagated by CRLA and the DGRC for the Phase II RDRR project (Table 6). These plants need multiple years of growth to become large enough to be planted in heavily disturbed areas. Current numbers of containerized plants for this project are listed in Table 7.



Figure 12. Overwintered plants emerging from the snow (left). Potted plants prior to detritus removal (middle). Plant care at the Park’s nursery (right). Photos by Carrie Wyler.

Table 6. Plant propagation quantities for Phase II of the RDRR project as of fall 2021.

Zone	Scientific Name	Restoration Site	Facility	Quantity (# of plants requested)	Quantity as of fall 2021	Reason for Discrepancy
Skell	<i>Purshia tridentata</i>	Grotto Cove and Skell Head	DGRC	8	3	Only 9 seeds collected
	<i>Ceanothus prostratus</i>	For seed increase beds	DGRC	98	19	Only 27 filled seeds collected
	<i>Holodiscus microphyllus</i> var. <i>glabrescens</i>	Palisades Pullout	DGRC	60	30	Seed fill at 33%
	<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	For seed increase beds	CRLA	294	200	n/a
	<i>Ribes viscosissimum</i>	Grotto Cove and Skell Head islands	CRLA	46	57	n/a
Mt. Scott	<i>Alnus alnobetula</i> ssp. <i>sinuata</i>	Pumice Castle Overlook	DGRC	20	20	n/a
	<i>Penstemon davidsonii</i> var. <i>davidsonii</i>	For seed increase beds	CRLA	196	196	n/a
Kerr	<i>Alnus alnobetula</i> ssp. <i>sinuata</i>	Pinnacles Junction	DGRC	20	20	n/a
	<i>Ribes</i> sp.	Phantom Ship Overlook islands and Pinnacles Junction	CRLA	98	91	n/a
Dutton	<i>Raillardella argentea</i>	For seed increase beds	DGRC	196	0	2021 heat wave mortality
	TOTAL			1,036	636	

Planting and Seeding

One final round of revegetation work was completed in areas affected by Phase I of the RDRR project during the 2021 field season. A total of 1,335 plants were planted and 6,998 grams of seed

dispersed across Phase I sites needing follow-up revegetation work. Phase I sites that will still need to be addressed during Phase II of the project include: CWRD5, NWERD2.2, and NEERD3.1, as reestablishing plant cover in these areas remains challenging. Table 7 summarizes the seeding and planting accomplishments by seed zone for the 2021 season.

Table 7. 2021 Summary of restoration planting and seeding accomplishments by seed zone.

Seed Zone	Number of Restored Sites	Total Number Plants Planted	Total Amount Seed Broadcast (g)
South WRD	1	159	6,280
Central WRD	1	302	718
Northeast ERD	2	874	0
TOTAL	5	1,335	6,998

The eastern embankment of the Cleetwood Cove parking lot will continue to need slope stabilization and erosion control for revegetation efforts to be successful. This embankment was disturbed by contractors stacking cut logs on it when they were clearing trees to expand the parking lot. The embankment is steep and consists of loose pumice soil, which collapses when walked on. The site does not hold seed or water well, and it has been difficult to restore and revegetate. In 2019 large logs and rocks were put into place and areas were vertically mulched with little success. Every revegetation attempt creates more soil disturbance and erosion. In 2021, Botany staff planted 35 one-gallon pots of Hall’s sedge (*Carex halliana*) that was salvaged from a nearby area on East Rim Drive slated for upcoming disturbance (Figure 13). Hall’s sedge has a fibrous and rhizomatous root system, and it is hoped that it will create a root mat and hold back the sloughing soil. If found to be successful at stabilizing this slope after assessment in 2022, more will be planted on the embankment in the future.



Figure 13. Planting the steep and difficult to restore eastern embankment at Cleetwood Cove parking lot. Photo by Carrie Wyler.

Site Documentation and Monitoring

Yearly site documentation and monitoring has been completed for all sites that were restored as part of the Phase I RDRR project. For these sites, one-, two-, three-, and five-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 (Figure 14).



Figure 14. Site NWERD10 in 2016 (left) and in 2021 (right) showing vegetative recovery. Photos by Carrie Wyler.

In past years overview documents 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 each site and can be used in combination with monitoring forms as a way of tracking restoration progress from year to year at specific sites. Overview maps, photos, and complete site documentation and monitoring forms for all sites can be found on the Botany file server.

Monitoring results showed a clear pattern: restored sites that were protected from further impacts (e.g., vehicle damage, trampling) did markedly better than those that experienced additional and/or ongoing impacts. Fifty of the 62 restored sites are doing well, and vegetative recovery is progressing with no further action needed. The other 12 sites were either damaged by vehicle traffic, trampled by Park visitors, or have challenging site conditions (e.g., steep slopes, erosion, unstable soils) that make revegetation difficult. Supplemental planting and seeding in the future will continue to assist the recovery of restoration sites that are struggling, and some sites may need fencing and/or signage to protect them from further damage especially at the Watchman Overlook and Cleetwood Cove parking lot.

Special Status Plant Management

During the 2020 season, Phase II of the RDRR project was surveyed for special status plant species. Eleven rare plant populations were encountered in the project area that will need protections (e.g., installing orange fencing around a population buffer) during construction. Some of these rare plant populations will experience unavoidable impacts due to their occurrence in deep patch and edge stabilization treatment areas, in the road shoulder, in cracks between rock walls and pavement, or otherwise in the path of impact (Figure 15).



Figure 15. Some rare plants will experience unavoidable road construction impacts such as shaggy hawkweed (left) and Shasta arnica (right). Photos by Jen Hooke.

In these cases, rare plants will be salvaged ahead of construction and held over at the Ball Diamond nursery until they can be replanted. In 2021, 135 Crater Lake rockcress, 90 undescribed species of rockcress, and 10 pumice moonwort were salvaged from two different sites on East Rim Drive. Additional rare plant salvage will need to occur in future field seasons as the construction project progresses. Seed was also collected from rare plant species in the immediate path of construction impacts. Quantities of seed collected from rare plants in Phase II projected construction areas is displayed in Table 8. Spatial and population data are housed on the Botany file server.

Table 8. Rare plant seed collected in 2021 from the RDRR Phase II project zone.

Seed Zone	Plant species	Seed collected (g)
Vidae	<i>Arnica viscosa</i> (Shasta arnica)	9
Mt. Scott	<i>Boechera</i> undescribed	1
Mt. Scott	<i>Hieracium horridum</i> (shaggy hawkweed)	5
Skell	<i>Boechera horizontalis</i> (Crater Lake rockcress)	9
Skell	<i>Hieracium horridum</i> (shaggy hawkweed)	1

Invasive Vegetation Management

A total of 31,268 invasive plants were treated in the project area during the 2021 season. Invasive plants were most frequently encountered at Rim Village. The number of invasive plants treated over the 2018 to 2021 field seasons is displayed in Table 9. Maps of invasive plant locations for 2021 are

displayed in five zones: East Rim Drive, Ball Diamond, Pole Bridge Creek Quarry, Rim Village Lodge, and Rim Village Café (Figures 16-21). No invasive plants were found on West Rim Drive during the 2021 field season. A new population of sheep sorrel (*Rumex acetosella*) was discovered in a meadow near Skell Head overlook in 2021. Also, in 2021 a new-to-CRLA invasive plant species, hairy bittercress (*Cardamine hirsuta*), was discovered at the Park’s Ball Diamond where the Park’s native plant nursery is located. This plant was brought in on a shipment of plants from the DGRC and has been targeted for eradication so that it does not spread beyond the nursery area.

Table 9. Invasive plant abundance (number of plants) within the RDRR project area from 2018--2021.

Region	Invasive Plant Species	2018 Abundance	2019 Abundance	2020 Abundance	2021 Abundance
Pole Bridge Creek Quarry	Bitter winter cress (<i>Barbarea vulgaris</i>)	9	95	4	1
	Common dandelion (<i>Taraxacum officinale</i>)	0	0	13	13
	St. John’s wort (<i>Hypericum perforatum</i>)	0	0	8	0
	Erect cinquefoil (<i>Potentilla recta</i>)	0	0	20	0
East Rim Drive	Bitter winter cress (<i>Barbarea vulgaris</i>)	2	0	0	7
	Canola (<i>Brassica napus</i>)	2	0	2	0
	Smooth brome (<i>Bromus inermis</i>)	130	0	500	0
	St. John’s wort (<i>Hypericum perforatum</i>)	0	0	6	4
	Canada bluegrass (<i>Poa compressa</i>)	0	200	0	0
	Kentucky bluegrass (<i>Poa pratensis</i>)	0	0	38	0
	Sheep sorrel (<i>Rumex acetosella</i>)	0	80	0	4,000
	Common dandelion (<i>Taraxacum officinale</i>)	36	585	277	330
West Rim Drive	Sheep sorrel (<i>Rumex acetosella</i>)	0	12	0	0
	Timothy (<i>Phleum pratense</i>)	1	0	0	0
Ball Diamond	Hairy bittercress (<i>Cardamine hirsuta</i>)	0	0	0	75
	Hairy cat’s-ear (<i>Hypochaeris radicata</i>)	0	0	0	1
	Red sand-spurrey (<i>Spergularia rubra</i>)	**	**	50	104
Rim Village	Bitter winter cress (<i>Barbarea vulgaris</i>)	98	294	178	9
	Common mouse-ear chickweed (<i>Cerastium fontanum</i> ssp. <i>vulgare</i>)	1	0	0	0
	Orchard grass (<i>Dactylis glomerata</i>)	0	0	0	1

Region	Invasive Plant Species	2018 Abundance	2019 Abundance	2020 Abundance	2021 Abundance
	Field cress (<i>Lepidium campestre</i>)	0	1	0	0
	Yellow sweet clover (<i>Mellilotus officinalis</i>)	0	0	10	0
	Buckhorn plantain (<i>Plantago lanceolata</i>)	1	3	2	0
	Common plantain (<i>Plantago major</i>)	0	3	0	0
	Annual bluegrass (<i>Poa annua</i>)	0	0	75	270
	Common knotweed (<i>Polygonum aviculare</i> ssp. <i>depressum</i>)	305	3,930	1,730	4,805
	Sheep sorrel (<i>Rumex acetosella</i>)	7,267	1,719	2,942	1,366
	Wood groundsel (<i>Senecio sylvaticus</i>)	0	0	0	6
	Red sand-spurrey (<i>Spergularia rubra</i>)	6,142	69,174	28,050	20,140
	Common dandelion (<i>Taraxacum officinale</i>)	73	69	27	80
	Yellow salsify (<i>Tragopogon dubius</i>)	0	0	0	1
	Dutch clover (<i>Trifolium repens</i>)	102	128	15	55
	Total	14,888	76,840	42,156	31,268

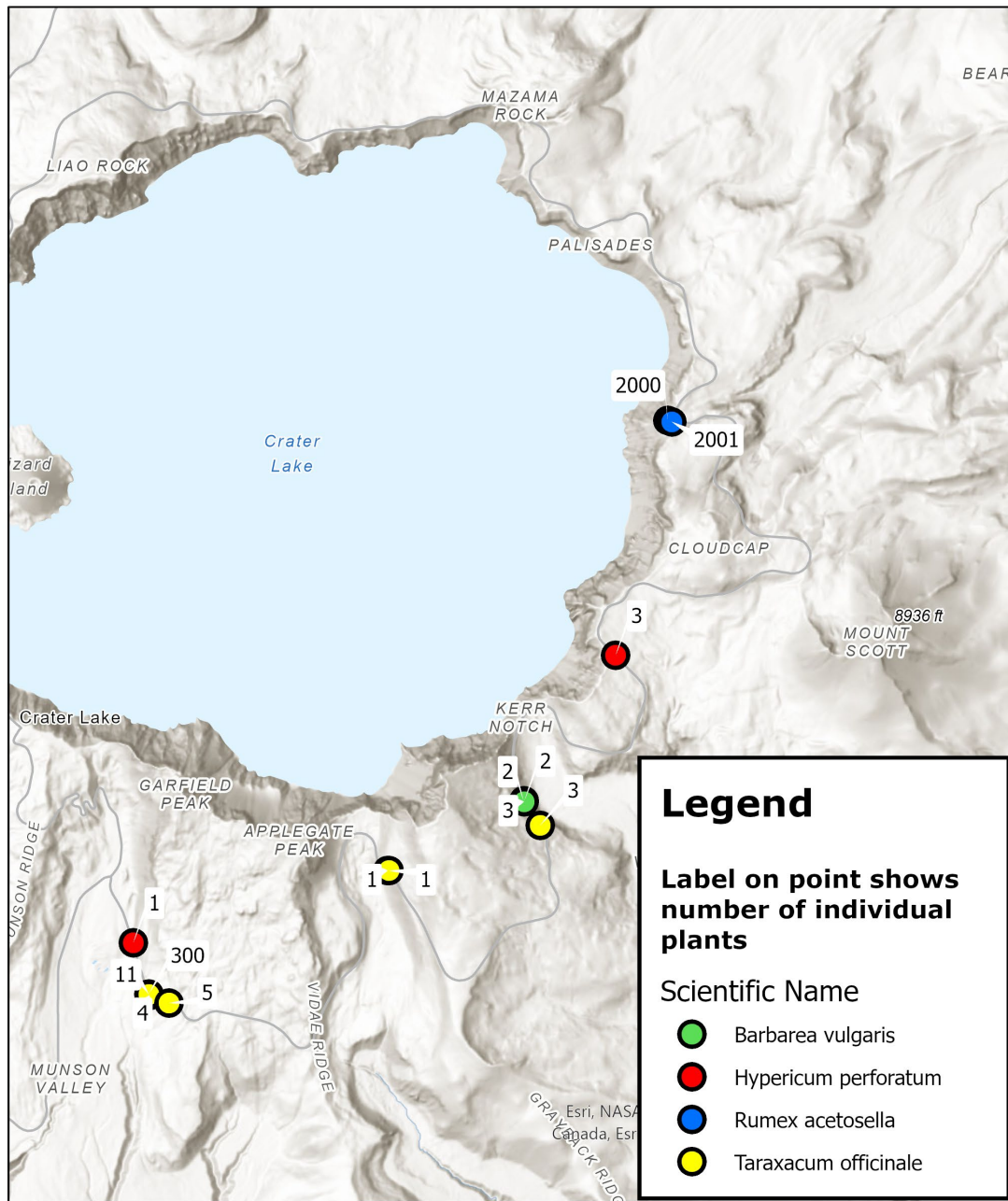
**No data available.

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East Rim Drive - Invasive Vegetation Populations 2021



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0 1 2 3 4 Kilometers



Coordinate System:
NAD 1983 UTM Zone 10N

Date: 11/4/2021

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Figure 16. Map of invasive populations treated in the RDRR project area on East Rim Drive. Map by Scott Heisler.

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Ball Diamond Staging Area - Invasive Vegetation Populations 2021



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0 25 50 75 100 Meters

Coordinate System:
NAD 1983 UTM Zone 10N



Figure 17. Map of invasive populations treated in the RDRR staging project area at the Park's Ball Diamond. Map by Scott Heisler.

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Pole Bridge Quarry Staging Area - Invasive Vegetation Populations 2021



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Date: 11/4/2021

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Figure 18. Map of invasive plant populations treated at the Pole Bridge Creek Quarry staging area. Map by Scott Heisler.

Large populations of common knotweed (*Polygonum aviculare* ssp. *depressum*), sheep sorrel, and red sand-spurrey (*Spergularia rubra*) at Rim Village were treated as time allowed. The large population of sheep sorrel by the Crater Lake Lodge has been subject to a large control effort annually since 2013, often using volunteer groups. This site was first treated with herbicide in the fall of 2017 and has been treated annually since. Sheep sorrel abundance was greatly reduced in 2018 and 2019, which may be attributable to the effectiveness of chemical treatment (Figure 19). In 2020 two new population areas were discovered which led to an increase in numbers from 2019, but numbers were again diminished during the 2021 field season. Common knotweed is another species that continues to increase greatly in number for unknown reasons, especially around the Lodge and in parking lot cracks (Figure 19). This is another difficult species to treat by manual means due to its deep root systems and tendency to occur in pavement cracks and crevices.

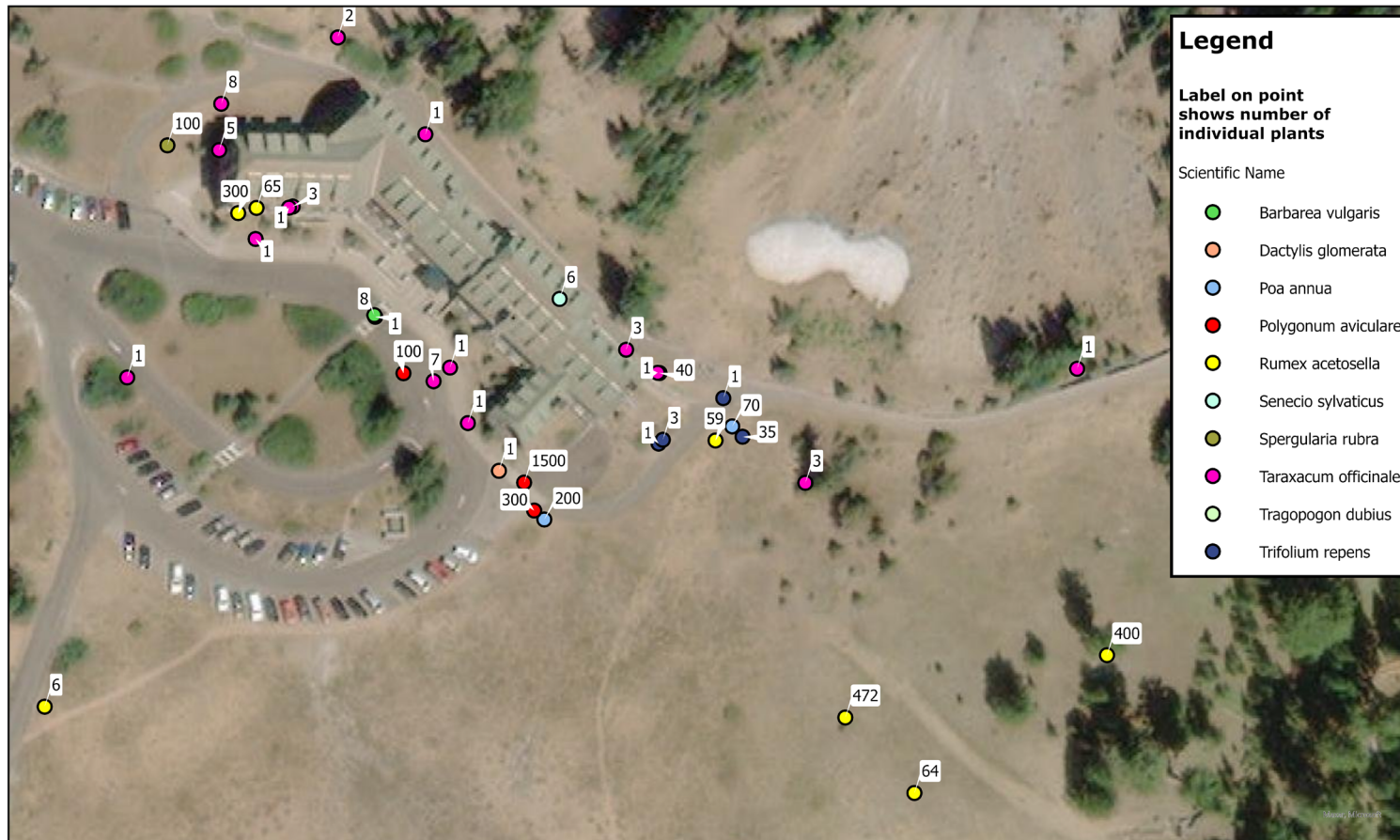


Figure 19. Chemically treating sheep sorrel at the Crater Lake Lodge meadow (left). Chemically treated common knotweed in a parking lot crack behind the Rim Village Café and Gifts building (right). Photos by Carrie Wyler.

Crater Lake National Park

Crater Lake Lodge - Invasive Vegetation Populations 2021

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Legend

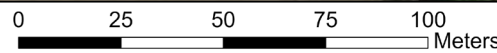
Label on point shows number of individual plants

Scientific Name

- *Barbarea vulgaris*
- *Dactylis glomerata*
- *Poa annua*
- *Polygonum aviculare*
- *Rumex acetosella*
- *Senecio sylvaticus*
- *Spargularia rubra*
- *Taraxacum officinale*
- *Tragopogon dubius*
- *Trifolium repens*

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Coordinate System:
NAD 1983 UTM Zone 10N
Date: 11/4/2021



Document Path: R:\GIS\UserMaps\002_NonnativePlants\Projects\2021\RevegIVM\RevegIVM.aprx

Figure 20. Map of invasive plant populations for the RDRR project area around the Rim Village Lodge. Map by Scott Heisler.

Discussion

During the 2021 season all remaining revegetation work was completed for Phase I of the RDRR project, with the exception of problematic sites needing additional troubleshooting efforts. Wrap-up efforts for Phase I focused on areas that needed additional assistance with recovery such as highly visited and trampled areas. During 2019, 2020, and 2021 large rock rings were made around grouped plantings at the Cleetwood Cove parking lot, Glacial Scratches pullout areas, and Watchman Overlook. This technique has been found to be successful in deterring trampling if larger rocks are used and will be used in future restoration areas. Some areas may need more obvious exclusion methods such as fencing and signage.

Recommendations and needs for RDRR work in the 2022 field season include:

- All plants that overwintered in 2021/2022 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. If plants aren't transplanted, many will die due to being extremely root-bound. Care should be taken to not expose newly transplanted plants to water, light, or temperature shock. All containerized plants should be checked for moss, liverwort growth, and weeds and they should be removed if present.
- 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. The entire project area needs to be thoroughly surveyed (e.g., walked) for invasive plants at least twice throughout the 2022 field season.
- The National Weather Service has an extremely useful weather database with daily, monthly, and yearly data summaries (<http://w2.weather.gov/climate/xmacis.php?wfo=mfr>) that should be used to help inform when to water newly planted seedlings and provides information for seed collection. It also facilitates year-to-year comparisons by providing data on annual snow loads and precipitation amounts.
- Restoration prescriptions will need to be developed for Roundtop Quarry. Its slopes were mechanically recontoured by the Phase I contractors leaving the disturbed areas completely devoid of vegetation. Once the Park has determined the desired footprint for future use of this area, disturbed areas outside this footprint need to be revegetated and restored. Some of the seed produced by the Meeker PMC can be used at this site. Seed will need to be raked in with Park compost and native debris distributed. The area will need to be mapped, documented, and monitored in Phase II for restoration progress and surveyed diligently for invasive plant species.
- While most restoration sites are recovering well, a few sites continue to need follow-up work. Site CWRD5 needs erosion issues addressed during Phase II of the Rim Drive Project before it can be revegetated. Sites NEERD2 and NEERD2.1 were obliterated pullouts immediately

west of the Cleetwood Cove parking lot. However, Park visitors have been parking on these areas and creating additional disturbance due to lack of parking at the Cleetwood Cove parking lot. These sites need barriers to prevent parking impacts prior to implementation of revegetation efforts.

- Restoration work has begun at site NEERD3, which is the Cleetwood Cove parking lot. Construction work at the comfort stations and ticket booth sites was not completed until the fall of 2019. Landscaping islands and beds in the parking lot have been revegetated, but these areas are heavily trampled by visitors which presents challenges to restoration. These areas will need to be assessed yearly for traffic patterns and trampling and filled in with plants as problem areas arise. Additional barriers (fencing) may be needed to protect the newly established vegetation. Installation of fencing was not possible in the front of the parking lot due to a buried gas line's unknown location. To protect young vegetation until it is large enough to be visible by parking lot users, plants were placed in groups and circled with large rocks to form a barrier (Figure 22). Each year additional plants will be added, and the rock circles expanded.
- The back of the Cleetwood Cove parking lot will be worked on during Phase II of the RDRR project. The area presently is not big enough for large recreational vehicles to pass through and their back wheels often jump the curb and damage this revegetation site. This area has been sparsely planted in areas that would not be impacted by vehicle traffic (Figure 22). After construction work is completed, more plants will be added.



Figure 22. Plantings in groups with rock borders to mitigate trampling in heavily trafficked Cleetwood Cove parking lot areas (left). The area at the back of the Cleetwood Cove parking lot will be adjusted to allow for RVs to drive around the comfort station (right). Photos by Carrie Wyler.

- Site NEERD 3.1 is the eastern embankment of the Cleetwood Cove parking lot and will need to be addressed in future years. It has a steep slope of pumice soil that is continuously eroding and hindering restoration efforts. The area will need to be assessed for success from the 2021 plantings. If successful, more plants will need to be planted on the embankment; more Hall's sedge may be needed for this endeavor.

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Appendix A

CRLA RDRR Project Phase II: Master Revegetation List from 95% Plan Set (3/03/21)

ID#	Station	Lake/ NonLake	Page(s)	Type	Seed Zone	Location	Size (ft ²)	Oblit Type	Finish Date
1	28+ to 28+	Lake	D.3	Pullout to obliterate	Skell	Just past Cleetwood Cove	506	Berm	10/22
2	83+ to 88+	Lake	D.7/F.4	Correct trampling	Skell	Palisades Overlook		Hand	10/22
3	102+50	Lake	D.8/F.5	Shrink pullout	Skell	Palisades Point #1	483	Berm	10/22
4	104+50	Lake	D.8/F.5	Shrink pullout	Skell	Palisades Point #2	2,591	Berm	10/22
5	178+ to 181+	NonLake	D.13-14	Reestablish BOTPUM and BOEUND	Skell	Lower Grotto Cove		n/a	10/22
6	191+ to 192+	Lake	D.14/ F.7	Remedy trampled area	Skell	Upper Grotto Cove	2,251	Prep	10/22
7	225+ to 229+	Lake	D.17/F.8	Skell Head Overlook: replace soil in overlook landscaping beds	Skell	Skell Head Overlook	2,403	Prep	10/22
8	225+30 to 227+30	NonLake	D.17	Reestablish BOEHOR – Deep Patch	Skell	Skell Head		Deep patch	10/22
9	244+ to 248+	NonLake	D.18	Reestablish BOEHOR – Deep Patch	Skell	Bear Creek (just east of Skell Head)		Deep patch	10/23
10	287+ to 289+	Both	D.21	Reestablish HIEHOR	Mt. Scott	Scott Bluffs HIEHOR #2		n/a	10/23

ID#	Station	Lake/ NonLake	Page(s)	Type	Seed Zone	Location	Size (ft ²)	Oblit Type	Finish Date
11	295+ to 299+	Both	D.22	Reestablish HIEHOR	Mt. Scott	Scott Bluffs HIEHOR #1		n/a	10/23
12	311+ to 311	Both	D.23	Reestablish BOEUND	Mt. Scott	Scott Bluffs BOEUND		n/a	10/23
13	341+ to 342+	NonLake	D.25/ F.10	Restoration of trampled areas/pavement obliteration	Mt. Scott	Whitebark Pine Picnic Area		Rock	10/23
14	349+ to 350+	NonLake	D.25/ F.11	Trailhead landscaping	Mt. Scott	Mt. Scott Trailhead		Prep	10/23
15	APPR01 24+ to 25+	CC North	E.2/F.29	Shrink pullout	Mt. Scott	Mt. Scott Overlook	895	Berm	10/23
16	377+ to 378+	NonLake	D.27	Pullout to obliterate	Mt. Scott	On back side of Cloudcap	3,221	Berm	10/23
17	421+ to 426+	Lake	D.30/ F.12	Landscaping island; shrink pullout	Mt. Scott	Pumice Castle Overlook	3,579	Prep	10/23
18	447+ to 448+	Lake	D.32/F.1 4	Pavement obliteration	Mt. Scott	Reflection Point	245	Rock	10/23
19	464+ to 465+	NonLake	D.33	Pullout to obliterate	Mt. Scott	South of Reflection Point	1,276	Berm	10/24
20	498+ to 498+	NonLake	D.35	Pullout to mostly obliterate (1 car)	Kerr	Just north of Anderson Bluffs	1,034	Rock	10/24

ID#	Station	Lake/ NonLake	Page(s)	Type	Seed Zone	Location	Size (ft ²)	Oblit Type	Finish Date
21	~550	Lake	D.39/F.1 6	Landscaping islands	Kerr	Kerr Notch		n/a	10/24
22	553+ to 556+	NonLake	D.39- 40/E.9/F. 17	Shrink roadway	Kerr	Junction w/ Pinnacles Rd at Kerr Notch	8,025	Berm	10/24
23	604+ to 606+	NonLake	D.43/F.1 9	Pullout to obliterate	Kerr	Upper Dutton Cliffs	5,424	Rock	10/24
24	644+ to 646+	NonLake	D.46	Pullout to obliterate	Dutton	DU01, Dutton Ridge	1,754	Rock	10/24
25	686+ to 688+	NonLake	D.48-49/ F.21	Shrink pullout	Dutton	Klamath Marsh Overlook	1,538	Rock	10/24
26	760+ to 764+	Lake	D.54/ F.26	Shrink parking lot; culvert replacement	Vidae	Sun Notch Trailhead	3,386	Prep	10/25
27	780+ to 786+	Both	D.55	Reestablish ARNVIS	Vidae	Vidae Cliffs		n/a	10/25
28	832+ to 836+	NonLake	D.59	Shrink parking area; improve area	Vidae	Vidae Falls	507	Rock	10/25
29	967+ to 967+	Lake	D.68	Pullout to obliterate	Vidae	Near CCWG	1,026	Berm	10/25

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April 2022

National Park Service
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