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Crater Lake National Park

Rim Drive Rehabilitation Revegetation Project

2016 Annual Report

ON THIS PAGE
Friends of Crater Lake volunteer collecting seed for revegetation efforts for the Rim Drive Rehabilitation project.
Photograph by Kathryn Williams.

ON THE COVER
Prostrate lupine (*Lupinus lepidus* var. *lobbii*) growing through the cracks of East Rim Drive.
Photograph by Carrie Wyler.

Rim Drive Rehabilitation Revegetation Project

2016 Annual Report

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

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

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

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Abstract

Crater Lake National Park's Rim Drive Rehabilitation Revegetation (RDRR) project aims to mitigate impacts to the rim environment from the Federal Highway Administration-sponsored Rim Drive Rehabilitation project. This major construction project will correct 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 2016 field season, over 29,590 invasive plants were removed from the project area including two new-to-the-Park non-native plant species. Additional rare plants were salvaged from areas prior to disturbance from construction activities and incorporated into a holdover facility where plants are monitored for health and survival. Overall salvaged rare plant survival rate was 67.9%, but this includes plants that were struggling at the time of last assessment and new recruits from seeds dropped in 2014, 2015, and 2016. For the fourth year in a row, plant materials were collected from five distinct seed zones representing the floral diversity of the project area. Fifty-one seed accessions were provided to the Corvallis Plant Materials Center by Park staff and contract crews for propagation of plants for revegetation and creation of customized seed mixes for each restoration site. Seed collection protocols were refined for each species targeted for use in revegetation to inform future restoration efforts. In 2016, CRLA staff planted 2,014 native plants and dispersed 2,499 grams of native seed throughout disturbed areas along East Rim Drive. On West Rim Drive, 854 native plants were outplanted in disturbed areas along with 273 salvaged rare plants; 500 grams of cleaned and 907 grams of uncleaned native seed were broadcast in disturbed areas along the road corridor.

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 Roads crew, especially Mike Stone and Steve Thomas, compiled, sorted, and transported large quantities of Park-sourced compost for use in restoration efforts. Planting assistance was received by members of the Crater Lake Invasive Vegetation Management staff, especially Lïv Bly and Michael Hernandez, and the Crater Lake Trails crew. Staff at the Corvallis Plant Materials Center, especially Amy Bartow, provided technical assistance with seed collection techniques. The Institute for Applied Ecology provided assistance with meeting seed collection targets. The U.S. Forest Service Dorena Genetic Resource Center provided excess Crater Lake National Park whitebark pine seedlings leftover from rust-resistance testing to be used in restoration activities as needed.

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 needed 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 of the Rim Drive Rehabilitation project commenced in 2015 and affects at least 5.9 miles of West Rim Drive, portions of East Rim Drive (e.g., North Junction to Cleetwood Cove; Grotto Cove), and the Rim Village parking lot. Several new disturbance areas were established in 2016 along West and East Rim Drive 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 landscaping islands in high visitor use areas. Additionally, road work displaced the world's largest known population of the Crater Lake rockcress (*Boechera 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.

Figure 1. One of the pullouts slated for obliteration and restoration along West Rim Drive. Photo by Seth Keena.

Due to the substantial impacts occurring to soils and vegetation, FHWA has 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 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 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. 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 October 2016, road construction crews have completed deep patch operations on East Rim Drive; rehabilitated West Rim Drive from Union Peak grade north to North Junction; and completed the Rim Village parking area. Work on the Cleetwood parking lot and trailhead is ongoing. One pullout along East Rim Drive has been obliterated, and four pullouts on West Rim Drive have been obliterated (some need additional contouring work prior to restoration). Work in 2017 will focus on finishing rehabilitation along West Rim Drive from Rim Village to Union Peak Grade; obliterating all remaining pullouts; completing the Cleetwood Cove area renovation; renovating 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.

Figure 2. Collecting seed and conducting restoration outplantings for the Rim Drive Rehabilitation project. Photos by Melody Frederic.

Table 1: RDRR restoration areas by location and completion status.

General Location	Type of Site/Location	Number to Restore	Restoration Complete?
West Rim Drive	Obliterated Pullout	13	No
West Rim Drive	Reduced Footprint of Parking Area (Lightning Springs, Last Snow, Glacial Valley)	4	No
West Rim Drive	Rare Plant Population Reestablishment (Watchman)	1	Yes (2016)
West Rim Drive	Unplanned Disturbed Areas	1	Yes (2016)
West Rim Drive	Landscaping (Watchman Overlook)	2	No
East Rim Drive	Obliterated Pullout	9	No
East Rim Drive	Roadway Realignment (Pumice Point, Grotto Cove)	2	No
East Rim Drive	Landscaping (Cleetwood Cove Parking Lot and Trailhead)	3	No
East Rim Drive	Rare Plant Population Reestablishment (Grotto Cove)	1	Yes (2014)
East Rim Drive	Llao Rock staging area	1	No
East Rim Drive	Roundtop Quarry	1	No
East Rim Drive	Unplanned Disturbed Areas	17	14/17 complete (2016)

Four Biological Science Technicians were devoted to the RDRR project in 2016; season length was from May 30 – October 28. In addition to working in areas to be 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 Roundtop Quarry, the Ball Diamond, and Pole Bridge Creek Quarry.

Efforts made by the RDRR program in 2016 can be organized into three components: (1) revegetation; (2) special status plant management, and (3) invasive vegetation management.

Methods

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

Revegetation

The project area was delineated into seed zones, with each 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 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 (Figure 4), 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), it was determined that using eight to ten plant species (accessions) per seed zone would be adequate for revegetation efforts (Table 2). Two pullouts slated for obliteration and rehabilitation at North Junction are physically located on East Rim Drive, but were lumped into the North WRD zone due to similarity of species.

Figure 3. Developing revegetation prescriptions for areas to be disturbed. Photo by Kathryn Williams.

Revegetation prescriptions were developed for each area slated for restoration starting in 2012 (Figure 3). The 2013, 2014, 2015 and 2016 RDRR crews continued with prescription development and adjustments to collect species for each seed zone. Each of the 52 sites (Appendix A) to be restored has a unique revegetation prescription derived by making visits to each site and recording the dominant plant species with an ocular estimate of each species' relative cover value. The number of plants and amount of seed to be used in revegetation efforts at each of the sites is outlined in a project-specific Revegetation Plan (Gregory et al. 2015).

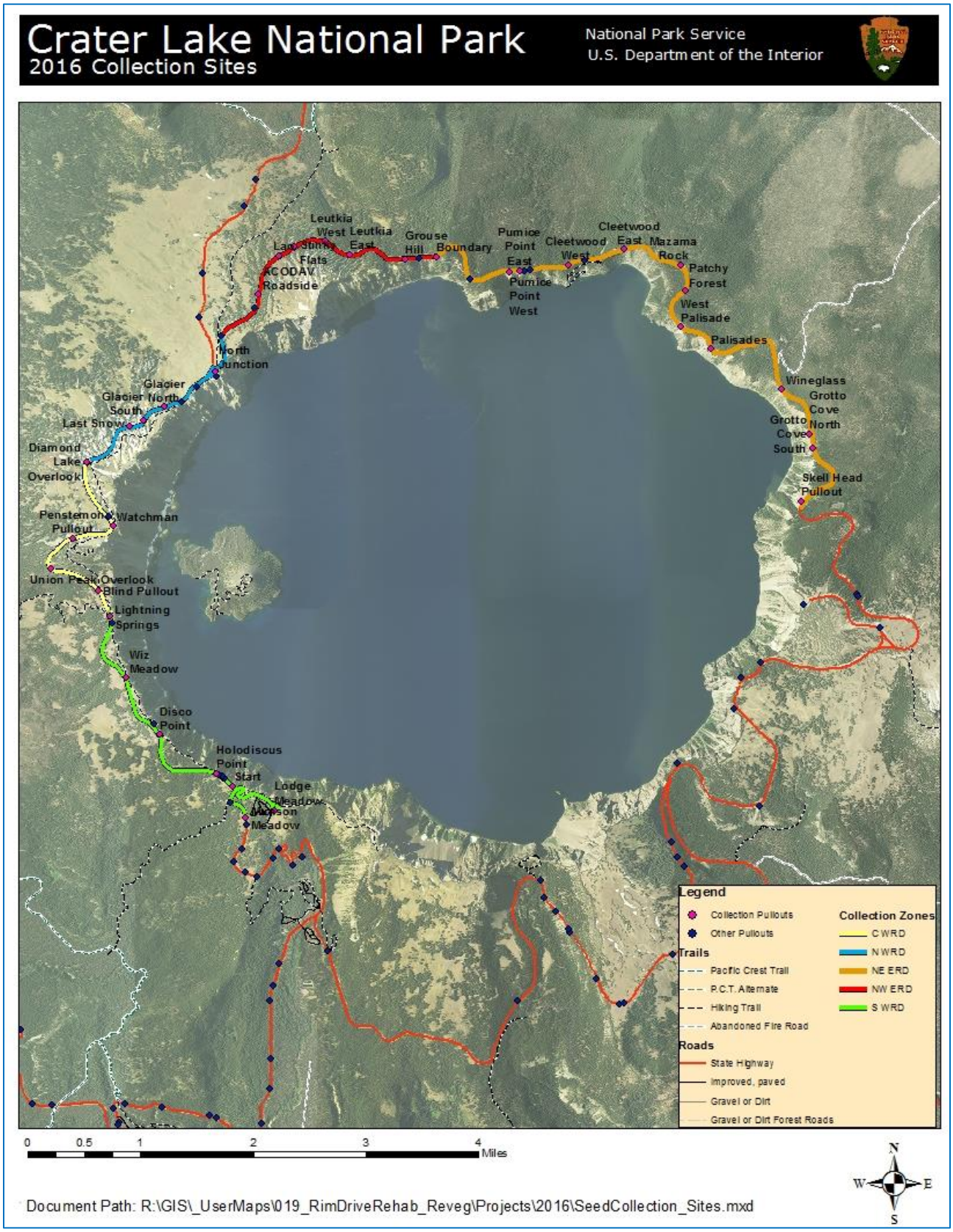

Figure 4. Seed collection zones with notable pullouts indicated. Map by Andrew Fraser.

Table 2: Rim Drive Rehabilitation Revegetation project target species listed by seed zones. S = seed collection and C = vegetative cutting. A total of 51 accessions were approved in 2016 due to scarcity of available seed in some species/zones.

Common Name	Scientific Name	South WRD	Central WRD	North WRD	NW ERD	NE ERD
Needlegrass	*Achnatherum occidentale*	S	S	S	S	S
Davis' knotweed	*Aconogonon davisiae* var. *davisiae*		S	S	S	
Western pasqueflower	*Anemone occidentalis*		S			
Pinemat manzanita	*Arctostaphylos nevadensis*					C
Green leaf manzanita	*Arctostaphylos patula*					C
Mt. Shasta arnica	*Arnica viscosa*			S		
Crater Lake rockcress	*Boechera horizontalis*		S			
California brome	*Bromus carinatus* var. *carinatus*	S				S
Brewer's sedge	*Carex breweri*			S	S	
Hall's sedge	*Carex halliana*	S				S
Many-ribbed sedge	*Carex pachycarpa*	S				
Applegate's paintbrush	*Castilleja applegatei*		S			
Cobwebby paintbrush	*Castilleja arachnoides*				S	
Squirreltail	*Elymus elymoides* ssp. *elymoides*	S	S	S	S	S
Cobwebby paintbrush	*Castilleja arachnoides*					
Greene's goldenweed	*Ericameria greenei*	S	S	S		
Showy rubber rabbitbrush	*Ericameria nauseosa* var. *speciosa*					S
Sierra eriogonum	*Eriogonum marifolium* var. *marifolium*	S	S	S	S	
Alpine buckwheat	*Eriogonum pyrolifolium* var. *coryphaeum*		S	S	S	
Bush ocean spray	*Holodiscus microphyllus* var. *glabrescens*	S				
Parry's rush	*Juncus parryi*				S	
Partridgefoot	*Leutkea pectinata*				S	
Anderson's lupine	*Lupinus andersonii*	S		S		
Prostrate lupine	*Lupinus lepidus* var. *lobbii*			S	S	S
Davidson's penstemon	*Penstemon davidsonii* var. *davidsonii*		S	S		
Compact phacelia	*Phacelia hastata* ssp. *compacta*					S
Spreading phlox	*Phlox diffusa*	S	S	S		

New areas for restoration were added in fall 2015 and summer 2016 after Deep Patch operations created unanticipated disturbance along East Rim Drive. Since the pre-disturbance vegetation community for these sites was destroyed and unavailable for use as a reference, a revegetation

prescription was developed from adjacent areas that guided planting and seeding efforts. Sites with gentler slopes that provided safe footing for the crew were planted and then seeds were spread over the area by hand broadcasting; steeper, unsafe slopes were only seeded through hand broadcasting.

Seed Collection

The 2016 seed collection efforts added to seeds collected during the 2013, 2014 and 2015 seasons. The seed collection process commenced in 2016 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 (Appendix B). A map was developed of all the specific seed collection locations for each species in each zone (Appendix C).

Field visits by the Corvallis PMC and DSC Revegetation specialists helped organize and plan for revegetation efforts in 2016. The Corvallis PMC staff recommended over-collecting on species that were abundant, as seed mix prescriptions could be supplemented with excess seed that could also be available to accommodate unanticipated disturbance areas. Species substitutions and a couple of species additions were approved to help fill in any gaps in the species accession list.

To maximize plant materials collected during the 2016 season, assistance from a contracted seed collection crew was obtained to collect from 'workhorse' species (those which were considered easy to identify, plentiful in their respective zones, producing copious amounts of seed per plant, and easily establishing via seed or plant plugs) to allow the CRLA Revegetation crew to focus on collecting seed from more difficult to collect from and/or less abundant species. The Institute for Applied Ecology (IAE) was assigned nine of the most readily available species: needlegrass (*Achnatherum occidentale)*, California brome (*Bromus carinatus* var. *carinatus)*, Oregon sedge (*Carex halliana*), common squirreltail (*Elymus elymoides* ssp. *elymoides*), Greene's goldenweed (*Ericameria greenei*), showy rubber rabbitbrush (*Ericameria nauseosa* var. *speciosa*), yellow-flowered wild buckwheat (*Eriogonum marifolium* var. *marifolium),* alpine buckwheat (*Eriogonum pyrolifolium*), and bush ocean spray (*Holodiscus microphyllus* var. *glabrescens*). The IAE made five collection trips over the course of the 2016 season and reported their findings (Getty 2017). The IAE assumed responsibility for cleaning and returning the cleaned seed to CRLA along with suggestions for mixing seeds from the border areas with an eye towards even distribution of seeds among zones.

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. In the field, bags were labelled with species code, collection date, and seed zone. After collection, seeds were transported to the seed drying and storage facility in the Stall Nine garage at Park headquarters (Figure 5). When seeds arrived at this facility, seed collection records were kept for each species with collection dates, specific collection location, and seed zone. Seeds were then either left in their bags or directly dumped inside 30-gallon plastic storage totes secured with window screen at the top, allowing ventilation while reducing chances of predation (Figure 6). 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 in a storage facility 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.

Figure 5. Seed drying and storage facility at the Stall Nine garage. Photo by Kathryn Williams.

Prior to shipping seed to the Corvallis PMC, all seeds from a single species with 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 lack of seed storage space at the Park, and inadequate ventilation for effective drying of damp material. During the 2016 season improvements were made to the seed storage area by adding battery powered fans and a humidity meter.

Figure 6. Western pasqueflower seeds drying in Stall Nine garage (left). Photo by Carrie Wyler. Centers of 30-gallon plastic tub lids were cut out to allow airflow, and screens secured to deter predation (right). Photo by Kathryn Williams.

Site Preparation

In 2014, a "vulnerability index" was developed for each of the original 31 planned disturbed sites to provide an estimate of restoration difficulty that could be linked with results of monitoring revegetation efforts. The vulnerability index compiled information on snowmelt timing, general soil conditions (amount of organic matter, water retention, and small mammal predation risk); soil hardness (presence of rocks); wind exposure; and canopy cover. These five factors were rated at each site, with final scores averaged into composite scores that were then assigned a letter grade of A-D, with "A" indicating good revegetation potential and "D" indicating harsh or challenging site conditions for revegetation. No vulnerability assessments were created for the additional unplanned disturbed sites in 2016 due to lack of time.

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

Beginning in 2016, Park-sourced mulch/compost and small coarse woody debris were acquired from Pole Bridge Creek Quarry for use in site preparation. With the aid of a large screen plant, partially composted woody debris was processed and sorted (Figure 7). 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.

Figure 7. A screen plant was used to sort readily compostable materials (left) from partially composted woody debris (right) to augment conditions at disturbed sites. Photos by Jen Beck.

Compost temperature was monitored over the season and was found to be high enough to indicate active biota degrading the material (Figure 8). The compost was used to provide a source of natural fertilizer for newly planted seedlings. The compost also helped create local microclimates, retain soil moisture, and provide microfauna to help promote the establishment and growth of the seedlings. The 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 restored sites as appropriate to assist with erosion control and site amelioration.

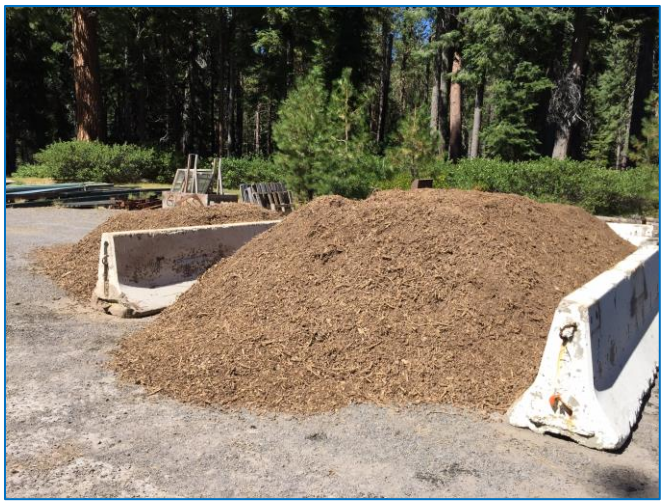

Figure 8. Compost pile used for restoration at the Park's South Yard. Photo by Jen Beck.

One area along East Rim Drive received a unique site preparation treatment due to the size and severity of disturbance it experienced (Figure 9). Due to the high amount of exposed mineral soil present at the Pumice Point comfort station, efforts were made to add organic matter to mitigate soil erosion and promote vegetative recovery. Disturbed slopes were manually re-contoured using hand tools. Ten 30-gallon tubs of duff and litter were salvaged from the Cleetwood parking lot expansion area in 2015 and broadcast across disturbed areas at the Pumice Point comfort station to cover exposed soils in early summer 2016. Larger-diameter organic debris was collected from the forested habitat behind the Pumice Point comfort station and disseminated across the site. Several 30-gallon tubs of smaller-diameter woody debris were added as additional soil amendments.

Figure 9. Excessive soil disturbance at the Pumice Point comfort station from driving equipment across slopes (left) and staging downed trees on slopes (right). Photos by Jen Beck.

Planting and Seeding

Since CRLA has not had the infrastructure or staff to support plant propagation or seed cleaning, an interagency agreement was developed by the Denver Service Center (DSC) Revegetation staff allowing the Corvallis PMC to perform these functions for the Park. During the 2016 season steps were taken to develop an on-site plant propagation and seed processing program at CRLA, decreasing CRLA's dependence on outside services. A steel shipping container (20'x10'x10') was procured and staged in South Yard to serve as a headhouse (Figure 9). A Weather Port Greenhouse, model WP-815-Gardenport (8'x 8'x15'), was obtained for plant propagation purposes and was staged in South Yard (Figure 9). Two seed increase beds (2'x4'x16') were constructed and positioned in the South Yard to maximize on solar radiation and growing season length (Figure 9). These efforts were further supported by a shade house (20'x20'x10') installed at the Ball Diamond adjacent to the smaller salvaged rare plant holdover facility. The shade house was used in 2016 to stage the delivered plants from the Corvallis PMC and allow them to acclimate to the Park's climate before being planted to improve the chances of successful establishment.

Figure 10. Improvements to CRLA's Revegetation program during the 2016 season: shadehouse (top left); shadehouse used to stage plants delivered from the Corvallis PMC (top right); headhouse and frame of greenhouse (bottom left); and seed increase beds (bottom right). Photos by Jen Beck.

In September 2016, CRLA received 15,318 native plants and 8,912 g of seed from the Corvallis PMC. The plants were stored under a shade house (Figure 11) in the ball diamond and cared for until planting. The plants were fertilized as prescribed by the Corvallis PMC employees. Excess growth was manually trimmed with scissors or hedge clippers as needed. Any reproductive structures were removed to promote root development and prevent excess evapotranspiration, and dead growth was removed to discourage fungal growth. Undesired plant volunteers originating from the Corvallis PMC in the planting tubes (e.g., moss, liverworts, and weeds) were removed before planting to minimize the risk of introducing non-native species to the park. Excess Park-sourced whitebark pine seedlings leftover from rust-resistance screening were provided to the Park by the U.S. Forest Service Dorena Genetic Resource Center. These will be used to augment restoration efforts in whitebark pine habitat.

Figure 11. Plants grown from CRLA seed by the Corvallis PMC staged in the shade house at the Ball Diamond. Photo by Jen Beck.

When the ambient temperature dropped below freezing the containers were consolidated and mulch was stacked around the bases of herbaceous plants to prevent root freezing. Four by four wooden beams were placed around the manzanita (*Arctostaphylos* sp.) shrubs. Above-average snowfall for October helped insulate the plants from freezing temperatures (Figure 12).

A mix of plant species was planted in the disturbance areas in accordance with the prescriptions and actual availability of species, compost was added, and plants were watered (Figure 13). Site-specific seed mixes were prepared and hand broadcast over planted areas, and over areas that were too steep to plant. After broadcasting, the sites were scarified with hand rakes and compost was broadcast over the scarified areas. The plants were watered from a truck mounted tank (Figure 13) until they were covered with snowfall.

Figure 12: Plants under snow in the shadehouse. Photo by Carrie Wyler.

At restoration sites, holes were dug to a depth equal to or greater than the length of the 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 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. Plant cones/tubes were left at the site of the plantings to ease watering and mulching by identifying planting sites. After mulching, the plants were all watered at least once and cones/tubes were removed. A 200 gallon water tank was purchased and mounted in the bed of a truck on a wooden pallet. An electric pump was purchased and used with the tank to facilitate watering of newly planted plugs.

Figure 13. Planting along the Watchman grade (left). Watering newly planted and mulched plants from a truck-mounted tank (right). Photos by Carrie Wyler.

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 or will be impacted. This includes populations of rare plants such as Mt. Shasta arnica (*Arnica viscosa*), pumice grapefern (*Botrychium pumicola*), Crater Lake rockcress (*Boechera horizontalis*), 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 has been displaced by this project. To mitigate impacts to the Park's special status

plant species, the RDRR program is charged with collecting baseline information on pre-disturbance special status plant populations; collecting seed from rare plants for propagation and revegetation; protecting whitebark pine from construction impacts; salvaging rare plants and caring for and monitoring them at a holdover facility; transplanting salvaged plants back into their habitat post-disturbance; conducting supplemental planting of propagated rare plants; and monitoring reestablished populations to inform management.

Before construction commenced in 2016, the project area was again surveyed for special status plant species. While the 2014 Rockfall Mitigation project destroyed about a third of the Watchman Crater Lake rockcress population, road rehabilitation work in 2016 destroyed the rest of this population. Crater Lake Revegetation staff was able to salvage 487 new Crater Lake rockcress plants and collect native seed from this area before the roadside vegetation community was destroyed. Salvage operations in 2016 retrieved two Mt. Shasta arnica plants from West Rim Drive (resprouts). In 2016, seeds were collected from both salvaged and *in situ* Watchman Crater Lake rockcress populations. Seeds were dried and stored in the Park's storage facility and shipped to the Corvallis PMC.

Salvaged plants were watered and cared for on a weekly basis at the Ball Diamond holdover facility (Figure 14). During periods of abnormally cold temperatures (including snow and periods of frost/freeze), plants were covered with frost cloth until temperatures warmed above freezing. Salvaged plants were monitored in 2016 on 6/27, 8/3, and 9/6 for health, phenology, and survival.

Figure 14. Salvaged rare plants at the holdover facility at the Ball Diamond. Photo by Kathryn Williams.

During the 2016 season, 273 pots of Crater Lake rockcress and 1 Mt. Shasta arnica were replanted along the Watchman grade from October 10-12. Immediately following the planting, a series of storms blanketed the area in substantial snowfall that covered the ground throughout the month of October. This prevented the planting of the remaining salvaged plants.

Invasive Vegetation Management

Crater Lake National Park has assigned all of its 85 non-native 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 2016, the entire 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 hard to access due to active 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 three times by foot in their entirety, including access roads and around piles of materials.

Figure 15. Yellow rocket (Barbarea vulgaris) growing near the Crater Lake Lodge. Photo by Melody Frederic.

Presently control of invasive species at CRLA is largely limited to manual methods. Most invasive plants are hand-pulled or severed from the root below the ground surface using a digging knife. For rhizomatous species, care is taken to extract as much of the root mass as possible during control operations.

When invasive plants are encountered (Figure 15), 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. All plant parts capable of reproduction are bagged, removed from the site, and disposed of in the trash compactor at Park headquarters where they are hauled (in a closed truck) to the Dry Creek Landfill in White City, Oregon for burial. Vegetative parts incapable of reproduction are left to desiccate on site unless they present logistical or aesthetic problems for Park visitors, employees, and partners.

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

Seed Collection

Fifty-one seed accessions were collected, dried, and processed in 2016. Plant phenology was monitored beginning early in the season by weekly visits to collection sites, and then later in the season by seed collection data sheets kept in the seed drying storage facility. Plant phenology in 2016 was more similar to that of 2014 due to snowpack persistence. The first snow-free day at Park headquarters was June 3 in 2014, and June 13 in 2016. Initial 2016 seed collection began in mid-July for a handful of plant species at sites with lower elevations and/or southern aspects and continued through early October. The seed collection season was cut short by early-season storms that left the Rim Drive area blanketed with record high snowfall for the month of October. The peak seed collection for the bulk of plant species in most of the zones occurred from mid-August to early September (Table 3). Some plant species offered a long collection period due to multiple flowering episodes throughout the growing season. The CRLA Revegetation crew collected seeds from only certain species in 2016 due to the seed collection contract with the IAE and concerns that the IAE would not meet their seed collection targets if Park staff made overlapping seed collection efforts.

Table 3. 2016 Seed collection periods by plant species.

Common Name	JULY (early)	JULY (mid)	JULY (late)	AUG (early)	AUG (mid)	AUG (late)	SEPT (early)	SEPT (mid)	SEPT (late)
Needlegrass*^			←	—	—	—	—	—	→
Davis' knotweed						←	—	→	
Western pasqueflower							←	→	
Crater Lake rockcress*			←	—	—	→			
California brome^					←	—	—	→	
Brewer's sedge					←	—	—	→	
Hall's sedge^						←	—	—	→
Many-ribbed sedge				←	—	—	→		
Applegate's paintbrush						←	—	→	
Squirreltail^					←	—	—	→	
Greene's goldenweed^						←	—	—	→
Showy rubber rabbitbrush^							←	—	→
Sierra eriogonum^					←	—	—	—	→
Alpine buckwheat^					←	—	—	→	
Bush ocean spray^								←	→

Common Name	JULY (early)	JULY (mid)	JULY (late)	AUG (early)	AUG (mid)	AUG (late)	SEPT (early)	SEPT (mid)	SEPT (late)
Parry's rush					←	→			
Partridgefoot					←			→	
Anderson's lupine				←			→		
Prostrate lupine				←				→	
Davison's penstemon						←		→	
Compact phacelia					←		→		
Spreading phlox					←			→	

*Taxa with more than one flowering episode per season
^Seeds collected by IAE staff

Overall, seed collection efforts were heightened in 2016 due to assistance from the IAE (Figure 16). With the IAE's focus on collecting seed from workhorse species, the CRLA Revegetation staff collected greater quantities of seed from more challenging plant taxa including Anderson's lupine, Hall's sedge, Applegate's paintbrush, and Davis' knotweed. Deer and insect predation pose a major threat to developing Anderson's lupine seed, while predation from unknown insects significantly reduces seed viability for Hall's sedge and Applegate's paintbrush. Davis' knotweed continued to pose a challenge to 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 Davis' knotweed suggest root division/cuttings are viable means of propagating Davis' knotweed (Trindle and Fessner 2003); however, initial tests of this method by the Corvallis PMC were largely unsuccessful.

Figure 16. IAE staff collecting seed along East Rim Drive. Photo by Carrie Wyler.

Results of the 2016 seed collection effort by the IAE are summarized in a final report (Getty 2017). Due to many factors, most of the IAE's target seed weights were not achieved during the 2016 season (Table 4). Some of these factors include inclement weather during scheduled seed collection trips; insufficient seed collecting personnel on each trip; slightly unripe seed that in theory (and according to Corvallis PMC staff and DSC Revegetation specialists) should have matured while

drying never did; empty and unfilled seed; and miscommunication between IAE and Park staff about phenology and seed ripeness (Getty 2017). To account for the shortfalls, many of the deficiencies in 2016 were rolled over into 2017 targets for seed weights. In situations where the seed was not available on the landscape for rollover, substitute species were identified with target seed weights for 2017:

- Pussypaws (*Calyptridium umbellatum*): 0.4 lbs
- Cascade aster (*Eucephalus ledophyllus*): 0.5 lbs
- Parry's rush: 2.0 lbs
- Compact phacelia: 0.5 lbs

Table 4. Results from the 2016 IAE seed collection effort and plans for 2017 seed collection. PLS = pure live seed.

Plant Species	2016 PLS Weight (lbs)	2016 Target PLS Weight (lbs)	Adjusted 2017 Target PLS Weight (lbs)	2017 Comments
Needlegrass	1.79	5.0	9.00	Final target is same as original contract
California brome	5.65	5.0	10.50	Final target is same as original contract
Hall's sedge	2.69	3.0	1.00	Final target is same as original contract
Squirreltail	6.85	10.0	9.50	Final target is same as original contract
Sierra eriogonum[1] or Alpine buckwheat[2]*	1.67[1] 0.36[2]	4.0	5.97	Final target is same as original contract
Greene's goldenweed	0	1.5	0.50	Quantity revised downward. Quantity carried over in substitute species.
Showy rubber rabbitbrush	0	1.5	0.50	Quantity revised downward. Quantity carried over in substitute species.
Bush ocean spray	0.11	1.5	0.75	Quantity revised downward. Quantity carried over in substitute species.

*Target PLS weight was combined for *Eriogonum* sp. to a total of 4.0 lbs PLS for both species.

The IAE analyzed clean seed for viability and purity at the Oregon State University Seed Laboratory. Results of testing detected small amounts of weed seed in the total PLS weight for some species (Getty 2017). Since preventing the establishment of non-native plants is paramount to this project's success, cleaning of seed collected by the IAE will be performed by the US Forest Service Region 6 Bend Seed Extractory in 2017. Seed collected by the IAE in 2016 will be re-cleaned by the Bend Seed Extractory prior to its application within the Park.

Figure 17. Deep patch operations along East Rim Drive required unanticipated disturbance of areas including this slope. Photo by Carrie Wyler.

After deep patch operations along East Rim Drive ceased in 2015, a much larger disturbance footprint was realized than initially anticipated (Figure 17). To mitigate for the increased levels of disturbance, it was agreed to use the seed increase services of the Meeker PMC to increase the abundance of plant materials available for restoration. In fall of 2015, 714 g of California brome and 2,218 g of squirreltail seed were sent to the Meeker PMC for seed increase. The seeds produced at the Meeker PMC will be collected, cleaned, and shipped to the Park by fall of 2019 for use in broadcast seed application for restoration. To maximize seed yield, it was agreed to combine squirreltail seeds from all seed zones for seed 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. Expected production totals from the Meeker PMC are displayed in Table 5.

Table 5. Expected 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)	2019 PLS (lbs)
California brome – West Rim Drive zones	40	40	40
California brome – East Rim Drive zones	40	40	40
Squirreltail – all zones	75	75	75

The easiest plants from which to collect seeds include those from the grass (Poaceae) and sedge (Cyperaceae) families, although California brome plants should be checked for presence of smut prior to commencing seed collection. Crater Lake rockcress, Sierra eriogonum, prostrate lupine, and compact phacelia were fairly easy plants from which to collect seed, though the use of gloves while picking compact phacelia is recommended due to bristly plant parts. Davis' knotweed, Anderson's lupine, and spreading phlox were the most time-intensive plants from which to collect seed. For Davis' knotweed, leaf nodes were felt for hard bumps (seeds), and if seeds were felt, then the stem was harvested and bagged. For Anderson's lupine, seed capture was tricky as there is a brief window when seeds are mature and not lost to dehiscence, so some collections were made early to be sure not all pods were lost, and some inflorescences were bagged to capture mature seeds. Spreading phlox also has a short seed collection period. It produces fruit at terminal ends of branches and seeds need to be plucked one at a time, being careful not to trigger its propulsive seed dispersal mechanism.

Seed capsules of cobwebby paintbrush were highly susceptible to insect predation, so seeds were not collected from this species in 2016. Applegate's paintbrush inflorescences were collected when the entire stem turned straw-brown. Seeds were most efficiently collected from Parry's rush, partridgefoot, and Davidson's penstemon by clipping entire inflorescences. In 2016, two plants were added to the North WRD seed zone species list: Anderson's lupine and prostrate lupine; and two plants were added to the NW ERD seed zone species list: needlegrass and Sierra eriogonum. Additionally, western pasqueflower was added to the Central WRD seed zone species list in 2016, primarily for use in the Watchman Overlook parking area and downslope roadside areas.

Site Preparation

Prior to planting and seeding, all disturbed sites were first prepared for revegetation activities. This included working with FHWA and DSC Revegetation staffs to ensure each disturbed site blended in with the local topography and did not appear unnatural (Figure 18). Sites were inspected for evidence of soil compaction prior to planting/seeding (Figure 18). Sites were prepared as needed with hand tools to knock down berms, smooth out vehicle or other tracks or depressions, and smooth out and feather in the area as appropriate to mimic the surrounding environs. Woody debris, compost, forest debris, and herbaceous litter were added to disturbed sites as appropriate to augment and ameliorate site conditions to facilitate subsequent planting and seeding efforts.

Figure 18. An obliterated pullout with insufficient site preparation, as the restored area looks more like a "worm" of placed topsoil rather than a natural landscape feature (left). Checking for soil compaction in a recently disturbed area prior to planting and seeding (right). Photos by Ken Stella.

Planting and Seeding

Revegetation efforts had planned to accommodate scheduled disturbance along West and East Rim Drives in the fall of 2016. Road construction plans for the 2016 season included finishing all obliterated pullouts along East Rim Drive, in North WRD, and in approximately half of Central WRD. Accordingly, Park staff worked with the DSC Revegetation Specialists and the Corvallis PMC to have adequate plant materials (plugs and seed) available for revegetation. The contractor assigned to the Rim Drive Rehabilitation project fell behind schedule, and as a result the only areas

ready for restoration included unanticipated disturbance resulting from Deep Patch Operations and one obliterated pullout along East Rim Drive; and four obliterated pullouts along West Rim Drive, several of which lacked adequate site preparation. An abnormally snowy October (Figure 19) further compounded an already delayed construction schedule and resulted in not being able to finish restoring areas that were scheduled for restoration.

A large plant delivery was received by the Park on September 13 from the Corvallis PMC. Approximately 13,600 plants were delivered and staged in the shadehouse at Park headquarters (Table 6). The Corvallis PMC also delivered cleaned seed collected from CRLA native plants at this time.

Figure 19. Early abundant snowfall in October 2016 shortened the restoration window. Photo by Carrie Wyler.

Despite having few areas that were planned for restoration available due to delays in the contractor's work schedule, the CRLA Reveg crew was able to use plant materials to restore areas that experience unplanned disturbance (Table 1). Areas that were restored in 2016 are displayed in Table 6.

Table 6. Restoration accomplishments as of fall 2016.

Seed Zone	# Sites Restored	Total # Sites to be Restored	Fall 2016 Completion (%)
South WRD	0	6	0.0
Central WRD	2	9	22.2
North WRD	0	6	0.0
NW ERD	8	16	50.0
NE ERD	7	15	46.7

Over 10,000 plants that were not able to be planted were overwintered in the Ball Diamond (Table 6). Plants with less-than-optimal root development were planted first in seed zones where planting was possible due to areas being available for restoration. Plants exhibiting better root development and overall good health were selected for overwintering, with hopes of transplanting them into larger containers next spring and planting them next fall. The overwintered plants were covered with two feet of snow during the first weeks of October, but were snow-free again after warm, dry weather in early November. They were finally covered with a persistent snowpack in late November, and they currently are buried under 116" of snow. As soon as possible after snowmelt in spring 2017, the plants will be moved to the South Yard for transplanting operations.

Table 7. Native plants and seed delivered to the Park in 2016, along with remaining quantities to be used in 2017 (East and Bartow 2017).

Plant Species	2016 Plant Delivery (#)	2017 Plants Remaining (#)	2016 Seed Delivery (g)	2016 Seed Collection by Park staff (g)	2017 Seed in Storage (g)
South West Rim Drive Seed Zone					
California needlegrass	0	0	0	0	0
California brome	0	0	0	121	1,871
Hall's sedge	0	0	0	0	1,193
Many-ribbed sedge	0	0	0	955	2,961
Squirreltail	0	0	0	0	651
Greene's goldenweed	0	0	0	0	57
Sierra eriogonum	0	0	0	0	1,118
Bush ocean spray	0	0	0	0	86
Anderson's lupine	0	0	0	748	1,015
Spreading phlox	0	0	0	16	26
Central West Rim Drive Seed Zone					
California needlegrass	370	300	0	0	0
Davis' knotweed	190	*	0	59	59
Western pasqueflower	0	0	390	1,809	1,809
Crater Lake rockcress	950	*	0	18	23
Applegate's paintbrush	0	0	0	24	53
Squirreltail	900	700	90	0	0
Greene's goldenweed	0	0	124	0	0
Sierra eriogonum	500	*	730	0	0
Alpine buckwheat	285	*	48	0	0
Davidson's penstemon	220	*	101	93	93
Spreading phlox	290	*	0	32	32
North West Rim Drive Seed Zone					
California needlegrass	0	0	0	22	22
Davis' knotweed	300	*	0	46	46
Mt. Shasta arnica	0	0	0	0	17
Brewer's sedge	1,000	*	0	112	112
Squirreltail	1,500	500	0	0	0
Greene's goldenweed	0	0	0	21	101
Sierra eriogonum	130	*	0	0	0
Alpine buckwheat	0	0	0	0	0
Anderson's lupine	0	0	0	114	114
Prostrate lupine	0	0	0	100	100
Davidson's penstemon	300	*	0	0	0
Spreading phlox	0	0	0	20	20
Northwest East Rim Drive Seed Zone					
California needlegrass	300	100	0	0	0

Plant Species	2016 Plant Delivery (#)	2017 Plants Remaining (#)	2016 Seed Delivery (g)	2016 Seed Collection by Park staff (g)	2017 Seed in Storage (g)
Davis' knotweed	150	*	49	46	46
Brewer's sedge	0	0	152	58	58
Cobwebby paintbrush	50	*	0	0	26
Squirreltail	1,200	400	911	0	0
Sierra eriogonum		*	98	0	53
Alpine buckwheat	0	0	153	0	113
Parry's rush	225	*	200	146	206
Partridgefoot	300	*	211	52	240
Prostrate lupine	100	*	219	15	15
Northeast East Rim Drive Seed Zone					
California needlegrass	370	100	320	32	32
Crater Lake rockcress	0	0	0	0	14
California brome	900	400	0	0	0
Hall's sedge	0	*	126	42	156
Squirreltail	1,100	200	0	0	0
Showy rubber rabbitbrush	300	300	0	0	81
Prostrate lupine	200	*	46	54	23
Compact phacelia	280	*	101	97	97

* Indicates inventory was not completed prior to end of 2016 season. Inventory will be made during the 2017 field season.

Special Status Plant Management

Survivorship data for salvaged rare plants staged in the holding facility at the Ball Diamond were collected on June 27, August 3, and September 9. As of September 2016, the Crater Lake rockcress plants salvaged from the Watchman Grade site in 2014 experienced an overall survival rate of 67.6% - up from 64.9% in September 2015. These should be considered optimistic estimates, as many of the plants were noted as being "stressed" at the time of assessment. The apparent increase in survivorship is partly the result of seedlings emerging from dropped seed within pots, and possibly the tendency of the species to go dormant and appear dead before sprouting new basal rosettes. Although salvage plant seeds are collected each year, not all are captured, which is likely why there was some new recruitment in 2016. However, it is difficult to differentiate between a new rosette from a seed and one from an existing root so no exact count of new plants was possible. Salvaged Crater Lake rockcress survival rates by salvage area are presented in Table 8.

Table 8: Survivorship of Crater Lake rockcress plants salvaged from the Watchman Grade area as of September 6, 2016.

Watchman Salvage Area	Date of Salvage	# of Plants Salvaged	Side of Road	Site Description	Survivorship
Rockfall	7/24-29/14	140	East	Narrow, rocky ditch between cliffs and road	57.9%
South Pullout	8/21/14	182	West	Flat pullout with sand spurry	56%
North Pullout	8/27/14	23	West	Flat; plants found in southern 15' of pullout; NW end of population	56.5%
North Slope	8/27/14	162	West	Area between the north and south pullouts; slope up to 65%	79%
East Slope	9/15/14	43	East	Slope to 40%	88.4%
West Side	8/01/16	87	West	West side full stretch	95%
East Side	6/22-30/16	400	East	East side full stretch	85%

Two new Mt. Shasta arnica plants were salvaged in 2016. The three Mt. Shasta arnica plants salvaged in 2014 still survive, potted in the holding facility, but none of them produced seed in 2015. One of the two western white pines (*Pinus monticola*) salvaged in 2014 still survives.

The Watchman Grade Crater Lake rockcress population was replanted in September and October of 2016 (Figure 20). The salvaged and propagated Crater Lake rockcress were planted along with a variety of other species propagated at the Corvallis PMC, including Davidson's penstemon, squirreltail, and Sierra eriogonum. The one Mt. Shasta arnica salvaged from the Watchman area was also replanted into the disturbance area below the Watchman trail. The Watchman Grade disturbance areas were seeded with a mixture of local seeds collected before the majority of road rehabilitation occurred in 2016. Rare plant seeds were collected annually from 2013 to 2016, and were transported to the Corvallis PMC for cleaning and storage before being returned to CRLA. Other seeds were dried and stored in the Stall Nine garages at CRLA with their associated biomass to provide weight when scattered. The species collected

Figure 20. Planting the Watchman Grade area along West Rim Drive. Photo by Carrie Wyler.

included Parry's rush, squirreltail, brewer's sedge, Sierra eriogonum, Davidson's penstemon, and Davis' knotweed. The seeds were broadcast by hand over the disturbed area from a walking position on the paved section of road. Park-sourced compost was broadcast over the seeded areas. The areas within reachable distance from the edge of the road were scarified by hand raking.

Whitebark pine continued to be protected as feasible from road construction impacts. The roadway realignment at Pumice Point spared a cluster of whitebark pines growing near the new road corridor. These were protected by installing a stone retaining wall (Figure 21). The new stone wall at Glacial Valleys overlook required the removal of an existing wall that contacted a bole of a large whitebark pine cluster (Figure 21). The old wall was removed by hand and equipment was kept out of the root crown of this tree cluster during construction.

Figure 21. A stone retaining wall was installed to protect a whitebark pine cluster from roadway realignment impacts (left). An old stone wall growing against the bole of a whitebark pine cluster was carefully removed by hand (right). Photos by Jen Beck.

Invasive Vegetation Management

A total of 29,590 invasive plants were removed from project areas during the 2016 season. Invasive plants were encountered most frequently at Rim Village and along West Rim Drive. Most areas experienced a marked increase in invasive plant species this season (Table 9), which is not surprising given the amount of road construction the area is experiencing coupled with a large increase in visitation in 2016. A map of invasive plant locations is displayed in Figure 22.

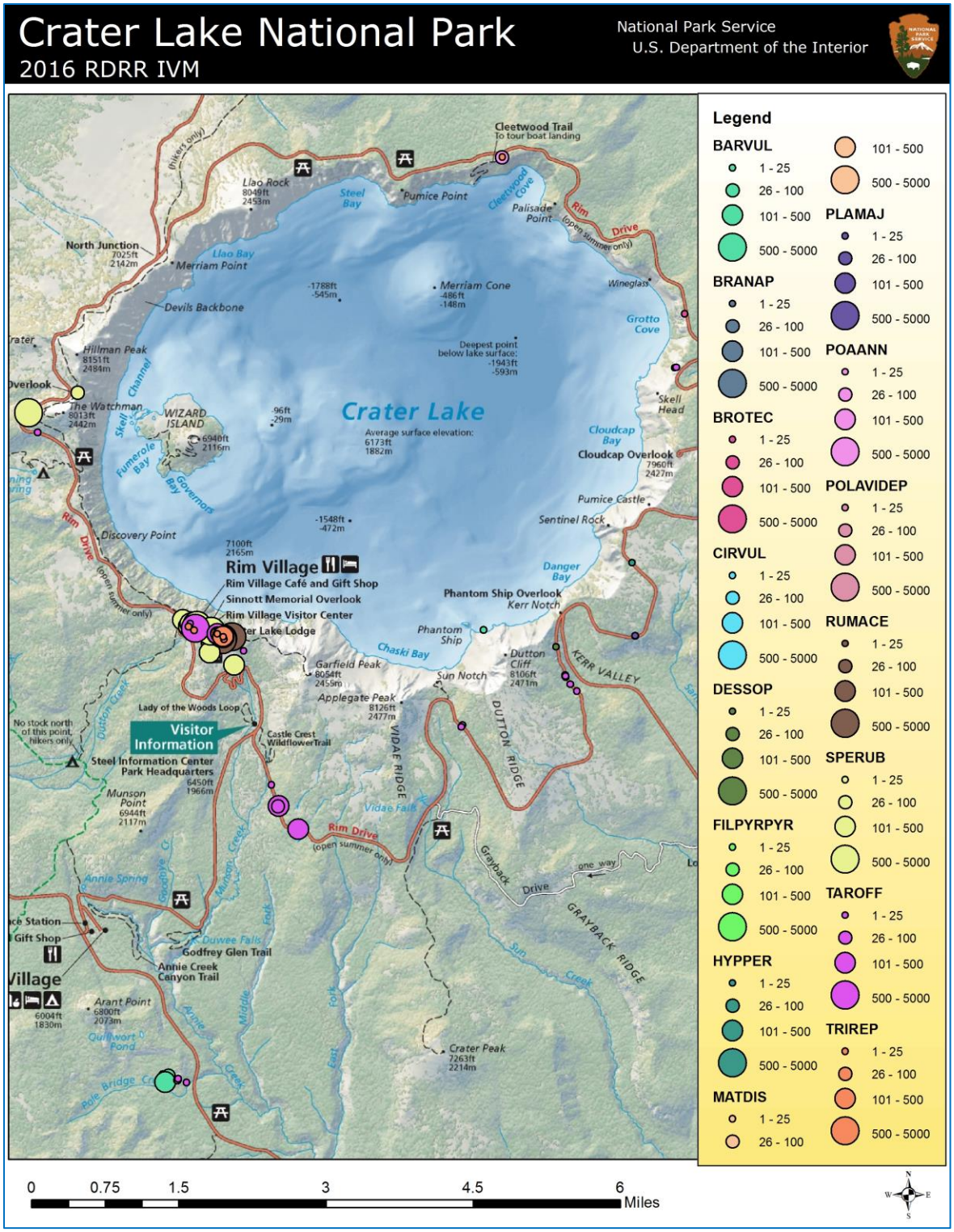

Figure 22: Treated invasive plant species by abundance in RDRR areas for 2016. Species codes: BARVUL = yellow rocket; BRANAP = canola; BROTEC = cheat grass; CIRVUL = bull thistle; DESSOP = flixweed; FILPYRPYR = cottonrose; HYPPER = St. John's wort; MATDIS = pineapple weed; PLAMAJ = plaintain; POAANN = bluegrass; POLAVIDEP = knotweed; RUMACE = sheep sorrel; SPERUB = sand spurry; TAROFF = dandelion; and TRIREP = white clover. Map by Jen Beck.

Table 9: Abundance (number of plants encountered) of invasive plant species within the RDRR project area for 2015 and 2016.

IVM Region	Invasive Plant Species	2016 Abundance	2015 Abundance
Pole Bridge Creek Quarry	Yellow rocket (*Barbarea vulgaris*)	227	184
	St. John's wort (*Hypericum perforatum*)	2	0
	Stinking pepperweed (*Lepidium ruderale*)	0	12
	Sand spurry (*Spergularia rubra*)	6	88
	Common dandelion (*Taraxacum officinale*)	4	0
East Rim Drive	Yellow rocket	4	0
	Canola (*Brassica napus*)	1	0
	Cheat grass (*Bromus tectorum*)	1	5
	Common flixweed (*Descurainia sophia*)	1	0
	St. John's wort	49	0
	Timothy (*Phleum pretense*)	2	0
	Common plantain (*Plantago major*)	1	0
	Annual bluegrass (*Poa annua*)	115	0
	Common knotweed (*Polygonum aviculare* ssp. *depressum*)	5	38
	Sand spurry	0	5
	Common dandelion	608	242
	White clover (*Trifolium repens*)	10	0
West Rim Drive	Yellow rocket	0	3
	Common knotweed	10	0
	Sheep sorrel	18	319
	Sand spurry	1624	1,939
	Common dandelion	1	3
Rim Village	Yellow rocket	363	1,084
	Bull thistle (*Cirsium vulgare*)	1	0
	Broadleaf cottonrose (*Filago pyramidata* var. *pyramidata*)	10	0
	St. John's wort	1	15
	Field pepperweed	0	5
	Pineapple weed (*Matricaria discoidea*)	601	38
	Common plantain	5	120
	Sheep sorrel	14,639	4,557
	Sand spurry	8,361	6,868
	Common dandelion	2,188	1,099
	White clover	1,328	633
	Flannel mullein (*Verbascum thapsus*)	1	0
	Total	29,590	18,237

Two new-to-the-Park weedy species were encountered within the project area in 2016: common flixweed (*Descurainia Sophia* – Figure 23) and canola (*Brassica napus*). Common plantain (*Plantago major*), pineapple weed (*Matricaria discoidea*), and St. John's Wort (*Hypericum perforatum*) populations were treated in their entirety with all observed individuals removed. However, large invasive plant populations of yellow rocket (*Barbarea vulgaris*), sheep sorrel (*Rumex acetosella*), and white clover (*Trifolium repens*) were treated as time allowed, and at the culmination of the field season there were multiple untreated populations still present. Sheep sorrel (which is rhizomatous) was treated in the entirety of its area but some individuals were undoubtedly missed, and some individuals had already resprouted by the end of the season. A recently formed Spanish Clover (*Lotus purshianus*) population was found in the Rim Village area for the first time this year, was treated in the Crater Lake Lodge landscape beds to preserve the historic appearance of the area (Figure 24). This species is adventive and has been spreading upslope from Highway 62.

Figure 23. Flixweed found along East Rim Drive in an area disturbed by the 2014 Rockfall Mitigation project. Photo by Andrew Fraser.

Figure 24. Landscaping bed adjacent to the Crater Lake Lodge partially filled with Spanish clover. Light green plants are Spanish clover (included in red perimeter). This was the first time this plant was found at the high elevations of the Rim environment. Photo by Andrew Fraser.

Discussion

This first phase of the Rim Drive Rehabilitation project is now over halfway complete, with deep patch operations finished on East Rim Drive, and road rehabilitation efforts complete in the north portion of West Rim Drive with partial completion in central West Rim Drive. Road rehabilitation still needs to be initiated in the south portion of West Rim Drive, and the Cleetwood Cove and Watchman Overlook parking areas need to be rehabilitated and/or expanded. This current phase of the Rim Drive Rehabilitation project is scheduled for completion in fall 2017; however, due to the contractor being behind schedule in many locations, it is possible that road rehabilitation may continue into the 2018 summer season.

The revegetation work load in 2017 is very large due to the fact that only one of the obliterated pullouts has been revegetated and restored (Appendix A). Additionally, it is likely that more areas along West Rim Drive will need revegetation due to more unanticipated disturbance similar to what was seen on East Rim Drive in 2015.

Implementation of a monitoring program to evaluate the success of restoration needs to occur during the 2017 field season. This could be achieved by matching records of what was planted and/or seeded at each disturbance site with long-term photopoints. Photopoints need to be established for all revegetated areas to track restoration progress. A monitoring protocol will be developed prior to the 2017 field season and implemented as restoration progresses in 2017. Monitoring is important for tracking efficacy of restoration efforts, identifying areas that need additional plant materials, and for aiding in the design of future projects by informing managers of effective techniques and pitfalls.

Additional recommendations and needs for RDRR work in the 2017 field season include:

- Continue to create, update, and refine revegetation prescriptions for each disturbance area, including areas that experienced unanticipated and excessive disturbance during road rehabilitation along West Rim Drive in 2016. Obtain area estimates of new disturbance areas and share with DSC Revegetation staff.

- Better coordination is needed with IAE to determine when they are finished with seed collection for each species to allow CRLA staff to collect additional seed that may become available.

- Seed collection can include additional species that aren't currently on species accession lists for seed cleaning/propagation services from the Corvallis PMC. These species can be cleaned in house, or if being used in the same season for restoration, can be stored until needed in the fall. Species should be chosen based on abundance in the specific area as well as ease of collection. Mixing these additional seeds into site-specific mixes will help bulk up seed amounts distributed to the sites, provide extra compost and carrying material, as well as fine-tune restoration prescriptions to reflect vegetation communities at unique sites.

- The RDRR program now has the ability to clean seed in-house. Any successful techniques and methods should be documented for each species and added to Appendix B, which can be amended to "Seed Collecting and Cleaning Protocols."

- The RDRR program now has the beginnings of a plant propagation program. Any attempts to propagate CRLA native species should be thoroughly documented to guide propagation efforts in the future. The Native Plant Network has propagation protocols for many species online: https://npn.rngr.net/propagation/protocols

- All plants that overwintered in 2016/2017 need to be transplanted into larger containers as soon as practical. The plants selected for overwintering were chosen because of their quick root development and overall plant hardiness. A sterile soil mix combined with a slow release fertilizer (such as Osmocote) and park pumice soil coupled with regular watering should provide enough root development to provide good plant stock for fall 2017 planting. If plants aren't transplanted, many will die due to being extremely root bound.

- The salvaged plants not being transplanted that remain from the 2016 season will need to be fertilized to assist with growth. There are currently no amendments added to the soil these plants are growing in.

- Continue to broadcast Crater Lake rockcress seed at the restored area along the Watchman Grade.

- Continue to survey previously known populations of invasive plants several times during the growing season. Prioritize survey and control in 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 for invasive plants at least twice throughout the field season.

- The common dandelion populations at Dutton Cliffs and Sun Notch have climbed high enough up the road cut that they will require use of an orchard ladder to access the plants. This will require invasive plant control during periods of low traffic (e.g., early morning) or removing them before East Rim Drive opens to public vehicle traffic in the spring.

- Continue to survey staging areas used by the 2014 Pavement Preservation project, including Pole Bridge Creek Quarry; Roundtop Quarry; the Ball Diamond; 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.

- 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 helps

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.

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Appendix A – RDRR Master Revegetation List

The Master Revegetation List corresponds with the construction plan sets for the Rim Drive Rehabilitation project.

Seed Zone	ID#	Name	Station (Plan Set)	Left/Right Side of Road	Page (Plan Set)	Disturbance Type	Location Description	Area (ft^2)	Planted/Seeded 2016?
South WRD	SWRD1	Start Left	1+04; 3+64	Lt	D.4	Pullout to obliterate	Near Rim Village	3,807	No
South WRD	SWRD2	Start Right	1+45; 4+11	Rt	D.4	Pullout to obliterate	Near Rim Village	1,818	No
South WRD	SWRD3	Holodiscus PO	11+28; 13+50	Lt	D.5	Pullout to obliterate	North of weather station	3,024	No
South WRD	SWRD4	Rocky	23+23; 24+08	Lt	D.5	Pullout to obliterate	North of weather station	900	No
South WRD	SWRD5	Disco Pt.	48+41; 53+53	Rt	D.7	Pullout to obliterate	South of Discovery Point	9,360	No
South WRD	SWRD6	Lightning Springs	117+43; 120+51	Lt	D.12; E.4	Shrink parking area	Lightning Springs Trailhead Parking	1,053	No
Central WRD	CWRD1	Blind PO	131+34; 132+91	Lt	D.13	Pullout to obliterate	North of Lightning Springs	3,465	No
Central WRD	CWRD2	Paintbrush PO	143+20; 146+02	Lt	D.13	Pullout to obliterate	Union Peak Grade	2,862	No
Central WRD	CWRD3	BOEHOR	160+65; 175+02	Lt/Rt	D.15	Rare plant reestablishment	Watchman Grade		Yes
Central WRD	CWRD4	BOEHOR/sand spurry PO	168+75; 169+50	Lt	D.15	Pullout to obliterate	Watchman Grade		No
Central	CWRD4.1	Below Watchman	186+25;	Rt	D.16	Road stabilization	Watchman Grade		Yes

Seed Zone	ID#	Name	Station (Plan Set)	Left/Right Side of Road	Page (Plan Set)	Disturbance Type	Location Description	Area (ft^2)	Planted/Seeded 2016?
WRD		Trail	189+75						
Central WRD	CWRD5	Rock island by road	200+25; 205+52	Rt	D.17; I.5	Landscape strip/islands	Watchman Overlook	4,257	No
Central WRD	CWRD6	Parking lot islands	200+20; 201+08	Rt	D.17	Landscape island	Watchman Overlook	4,059	No
Central WRD	CWRD7	Hillman south	213+89; 215+25	Lt	D.18	Pullout to obliterate	Hillman Peak	1,440	No
Central WRD	CWRD8	Hillman north	216+10; 217+29	Lt	D.18	Pullout to obliterate	Hillman Peak	1,890	No
North WRD	NWRD1	Last Snow PO	259+20; 264+53	Rt	D.21; E.6	Shrink parking area	Last Snow	3,726	No
North WRD	NWRD2	Last Snow PO	259+57; 264+14	Lt	D.21; E.6	Pullout to obliterate	Last Snow	4,005	No
North WRD	NWRD3	Devil's Backbone	269+48; 273+17	Lt	D.22	Pullout to obliterate	Devil's Backbone	3,690	No
North WRD	NWRD4	Devil's Backbone	279+35; 281+13	Lt	D.22, D.23	Pullout to obliterate	Devil's Backbone	1,810	No
North WRD	NWRD5	Grandmother Tree	297+18; 299+72	Rt	D.24, E.7	Shrink parking area	Glacial Valleys	2,565	No
North WRD	NWRD6	Combined with NWRD5	297+27; 299+24	Rt	D.24, E.7	Shrink parking area	Glacial Valleys		No
Northwest ERD	NWERD1	North Junction right	503+51; 507+03	Rt	D.26	Pullout to obliterate	North Junction	1,500	No

Seed Zone	ID#	Name	Station (Plan Set)	Left/Right Side of Road	Page (Plan Set)	Disturbance Type	Location Description	Area (ft^2)	Planted/Seeded 2016?
Northwest ERD	NWERD1.1	Directly next to NWERD1	502+06; 503+60	Rt	D.26	Ditch reconditioning	North Junction	5,743	Yes
Northwest ERD	NWERD2	North Junction left	503+93; 508+38	Lt	D.26	Pullout to obliterate	North Junction	4,440	No
Northwest ERD	NWERD2.1	North Junction deep patch	510+00; 513+40	Lt	D.26	Deep patch	North Junction	26,030	Yes
Northwest ERD	NWERD2.2	First staging area after North Junction	514+59; 522+44	Lt	D.27	Staging area erosion and damage	Llao Rock		No
Northwest ERD	NWERD3	Llao south	560+75; 564+21	Lt	D.28	Pullout to obliterate	Llao Rock	2,601	No
Northwest ERD	NWERD4	Llao north	566+91; 568+50	Lt	D.28	Pullout to obliterate	Llao Rock	2,133	No
Northwest ERD	NWERD4.1	First paved area after Llao north	573+08; 572+82	Lt	D.28	Road stabilization	Llao Rock	1,250	Yes
Northwest ERD	NWERD5	Luetkea west	588+42; 594+25	Lt	D.29	Pullout to obliterate	Grouse Hill	7,686	No
Northwest ERD	NWERD6	Luetkea east	603+35; 606+35	Lt	D.29/30	Pullout to obliterate	Grouse Hill	3,600	No
Northwest ERD	NWERD7	Grouse Hill Picnic Area island	631+76; 633+53	Lt	D.30	Ditch reconditioning	Grouse Hill	2,122	Yes
Northwest ERD	NWERD8	Roadside after Grouse Hill Picnic Area	633+75; 636+75	Rt	D.30/31	Deep patch	Grouse Hill Picnic	3,861	Yes

Seed Zone	ID#	Name	Station (Plan Set)	Left/Right Side of Road	Page (Plan Set)	Disturbance Type	Location Description	Area (ft^2)	Planted/Seeded 2016?
Northwest ERD	NWERD8.1	Lakeside area directly before Steel Bay	638+40; 639+18	Rt	D.31	Road stabilization	Steel Bay	3,125	Yes
Northwest ERD	NWERD9	Flat area across from Steel Bay	633+75; 636+75	Lt	D.30/31	Road stabilization	Grouse Hill Picnic	3,516	No
Northwest ERD	NWERD10	Across from Steel Bay PO	639+40	Lt	D.31	Culvert installation	Steel Bay	4,600	Yes
Northwest ERD	NWERD10.1	Roadside after Steel Bay PO	646+78; 647+71	Rt	D.31	Slope erosion	Steel Bay	580	Yes
Northeast ERD	NEERD0.01	Area between Steel Bay & Pumice Point Comfort Station	673+90; 676+70	Lt	D.32	Deep patch	Pumice Point	9,072	Yes
Northeast ERD	NEERD0.02	Right before PPCS	688+89; 691+04	Lt	D.33	Road stabilization	Pumice Point	9,680	Yes
Northeast ERD	NEERD0.1	PPCS	691+04; 693+31	Lt	D.33	Excessive disturbance	Pumice Point	4,160	Yes
Northeast ERD	NEERD1	Right after PPCS	696+21; 698+71	Rt	D.34	Road realignment	Pumice Point	8,850	Most
Northeast ERD	NEERD1.1	Pumice Point caldera slope	698+52; 697+07	Rt	D.34	Excessive disturbance	Pumice Point	3,200	Yes
Northeast ERD	NEERD1.2	Pumice Point unplanned ditch	719+33; 721+44	Lt	D.35	Wide ditch	Pumice Point	9,800	Yes
Northeast ERD	NEERD1.3	Pullout with drain across road	721+44	Lt	D.35	Culvert placement	West of Cleetwood Cove	648	Yes

Seed Zone	ID#	Name	Station (Plan Set)	Left/Right Side of Road	Page (Plan Set)	Disturbance Type	Location Description	Area (ft^2)	Planted/Seeded 2016?
Northeast ERD	NEERD2	Cleetwood west	731+89; 735+23	Lt	D.35/36	Pullout to obliterate	Cleetwood Cove	2,565	No
Northeast ERD	NEERD2.1	Paved area before Cleetwood (next to NEERD1.3)	732+40; 735+60	Rt	D.35/36	Deep patch	Cleetwood Cove	6,945	No
Northeast ERD	NEERD3	Cleetwood parking lot	738+74; 10+00	n/a	I.9	Landscape islands	Cleetwood Cove		No
Northeast ERD	NEERD3.1	Cleetwood parking lot	738+74; 10+00	n/a	I.9	Landscaping for visitor facilities	Cleetwood Cove	1,500	No
Northeast ERD	NEERD3.2	Excessive disturbance east slope	738+74; 10+00	n/a	I.9	Logs staged on slope	Cleetwood Cove		No
Northeast ERD	NEERD4	Past Cleetwood	739+31; 750+02	Lt	D.36	Pullout to obliterate	Cleetwood Cove	7,434	No
Northeast ERD	NEERD5	Past Cleetwood	742+38; 744+94	Rt	D.36	Pullout to obliterate	Cleetwood Cove	2,223	No
Northeast ERD	NEERD15	Grotto Cove	n/a	Lt/Rt	n/a	Realignment, stabilization	Grotto Cove emergency stabilization	6,860	No

Appendix B – Seed Collection Protocols

Life history and seed information has been taken from:
Baldwin, B.G., D.H Goldman, D.J. Keil, R. Patterson, T.J. Rosatti, and D.H. Wilken, editors. 2012. The Jepson Manual: vascular plants of California, second edition. University of California Press, Berkeley, California, USA.

Species: *Achnatherum occidentale* (ACHOCC); Needlegrass

Family: Poaceae

Life History and Seed Information: Plant is a perennial bunchgrass. Fruit is a caryopsis; spikelet with glumes > floret (except awn); one floret per spikelet; floret 5.5-7.5 mm.

Identification Tips: Two subspecies of *Achnatherum occidentale* occur in CRLA: *californicum* and *pubescens.* Per Zika (pg. 73) the two taxa occur in similar habitats and ranges and are distinguished "by minor differences in the length of the hairs at the summit of the lemma." Distinguishing between the two subspecies was not critical to the RDRR project.

Phenology and Seed Ripeness: Seeds are ready to collect when inflorescences begin to turn from a green to a straw color and awns begin to bend out (Figures C1, C2).

Needlegrass inflorescences with bent awns. Photo by Melody Frederic.

Seed Collection Techniques: There are two methods used to collect ACHOCC seed. The first method collects mainly seed/awn material by running fingers up the inflorescence. Use firm pressure, pinching the bottom of the inflorescence and run your fingers up to the inflorescence top – loose seed will come off between the fingers. The second method collects more biomass than the first, but it will likely net more total seed. Use scissors, clippers, or a rice knife to clip the inflorescence and place it in a large brown bag. By leaving the stem attached, any still-

developing seed can extract extra nutrients to help to ripen while drying in the bag. Avoid collecting seeds when they are too green, as seeds will not ripen.

Seed Collection Notes: An early seeder, many individual plants send up late-season flowering stalks providing two episodes of seed production.

Plans for Propagation: This species is to be re-established in all seed zones and is targeted for propagation by sowing and plug planting; ACHOCC was added to NW ERD in August of 2015.

Needlegrass inflorescences and seeds with bent awns. Photos by Melody Frederic.

Species: *Aconogonon davisiae* var. *davisiae* (ACODAVDAV); Davis' knotweed

Family: Polygonaceae

Davis' knotweed with developing seeds. Photo by Melody Frederic.

Life History and Seed Information: Plant is perennial from a woody caudex. Fruit is an achene, 4-4.5 mm, obovoid, brown, and shiny. Seed is single and attached to ovary wall at a single point.

Phenology and Seed Ripeness: As seeds begin to develop, the terminal leaves of the plant often begin to enclose the fruit. In general (but certainly not always), green plants contain immature seeds and, as seeds mature, plants begin to turn red. Seeds are fully mature when they turn from green to light brown. However, according to Corvallis PMC personnel, color doesn't matter as much as the seed's hardness; green seeds that are hard and doughy or powdery inside (i.e., with no liquid) should be viable and collectable.

Seed Collection Techniques: This species is quick to turn red, desiccate, and scatter with the wind. Once a few plants in a given population start to redden, start checking the plant for seed production and development. Feel the terminal ends of upper leaf axils for the presence of small, hard seeds. If seeds are felt, check a few seeds within the population for readiness. If the seeds are hardening and not milky inside it is time to start collecting. It is important to remember that a ripe seed is often more desiccated, and therefore smaller than a "greener" seed, so a productive ACODAVDAV stem may be hard to discern when a plant is nearing late phenology. Seeds from ACODAVDAV were collected by approaching reddening plants, feeling at the terminal & internodes for hard lumps (i.e., seed), then tearing-off seed-bearing stems from the plant and collecting them in a large bag. ACODAVDAV plants are often inhabited by small caterpillars which do not seem to affect the quality of the seed. This method of collection includes a lot of biomass, so it is important to keep mold from developing by either shipping it off to the Corvallis PMC immediately, or by stirring the collected material several times a week.

Additional Observations from 2016: Seed production varies greatly from one plant to another in a given population and from one population to another. Collection efforts were more successful in the North WRD and NW ERD seeds zones; the Central WRD seed zone was less prolific in 2015. 2016 was a much better collection year.

Plans for Propagation: This species is to be re-established in Central WRD, North WRD, and NW ERD and is targeted for seed sowing and plug production; containers will range from 4-6" diameter.

On August 7, 2014 Corvallis PMC personnel obtained cuttings from the NW ERD seed zone to experiment with the possibility of propagating this species through vegetative material, but vegetative reproduction efforts were unsuccessful. Another possible means of re-establishing this species is by marking plant locations before the current year's stems break-away, then in Fall, dividing and transplanting root systems. (ACODAV roots can grow quite deep). However, this method was not experimented with in 2015 or 2016. Propagation at the Corvallis Plant Materials Center was moderately successful. One observation relayed to CRLA was that the ACODAV plants that did sprout frequently (but not always) went dormant, dropping all above ground vegetative matter while leaving an apparently healthy tap root in the cone. A small number of these cones were beginning to show vegetative resprouting before they were replanted. It was assumed that these taproots were still viable and they were planted along with the cones that still showed vital vegetative growth.

Davis' knotweed seeds at maturity. Photos by Melody Frederic.

Species: *Arctostaphylos nevadensis* (ARCNEV); Pinemat manzanita

Family: Ericaceae

Pinemat manzanita in flower. Photo by Melody Frederic.

Life History and Seed Information: Plant is a spreading to decumbent perennial shrub. Fruit is a drupe, 6-8 mm wide, +/- spheric, glabrous; stones +/- separable.

Phenology and Seed Ripeness: This species will be propagated by cuttings. Corvallis PMC personnel collected cuttings in 2015 and plants developed very well.

Plans for Propagation: This species is to be re-established in NE ERD and is targeted for propagation by cuttings contained in D40 containers.

Species: *Arctostaphylos patula* (ARCPAT); Green leaf manzanita

Family: Ericaceae

Green leaf manzanita in bloom. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial shrub. Fruit is a drupe, 7-10 mm wide, glabrous, dark chestnut-brown.

Phenology and Seed Ripeness: This species will be propagated by cuttings. Corvallis PMC personnel collected cuttings in 2015 and did very well in plant development.

Plans for Propagation: This species is to be re-established in NE ERD and is targeted for propagation contained in D40 containers.

Species: *Arnica viscosa* (ARNVIS); Mt. Shasta arnica

Family: Asteraceae

Mt. Shasta arnica by Last Snow pullout. Photo by Melody Frederic.

Life History and Seed Information: Plant is perennial from woody, scaly caudex. Fruit is an achene, +/- cylindric, 5-6.6 mm, stalked-glandular; pappus is short-barbed to subplumose, gen white (brownish).

Phenology and Seed Ripeness: Although all located and known ARNVIS plants in the project area were salvaged during the Fall of 2014, one new plant (under the cliff near Devils Backbone) was located, and one plant resprouted (Last Snow, east side of road). One plant, found in early phenology near Watchman in 2014 and 2015, keeps getting browsed to the soil, making salvage elusive. The Watchman plant was salvaged in the spring of 2016. The Devils Backbone plant was a prolific seeder, and although a majority of the seeds escaped collection, quite a few were collected in small glassine envelopes. In 2014, we were unable to collect from this species as no flowers were available. All plants had stems gnawed off and buds infested by an unknown insect. However, in 2013 a small number of seeds were collected from late August to about mid-September; these seeds are now at the Corvallis PMC. In 2015 seeds were collected from the Watchman plant.

Mt. Shasta arnica plant on Wizard Island. Photo by Jen Beck.

Seed Collection Techniques: Seeds were collected by pulling pappus with achenes attached from seed heads.

Plans for Propagation: This species is to be re-established in North WRD and is targeted for plug production; containers will range from 4-6" diameter. This species also is selected for germination trials and propagation protocol development.

Species: *Boechera horizontalis* (BOEHOR); Crater Lake rockcress

Family: Brassicaceae

Life History and Seed Information: Plant is perennial from woody caudex. Fruit is a silique, straight or slightly curved with horizontal orientation extending from stem, glabrous, generally around 3 cm in length. Seeds are about 1 mm, round with narrow wing +/- all around perimeter.

The Crater Lake rockcress. Photo by Melody Frederic.

Identification Tips: Plant is distinguished from other *Boechera* spp. by the horizontal orientation of siliques extending from stem; flowers are deep purple with no white flowers.

Phenology and Seed Ripeness: In 2015 and 2016, seeds from both the potted salvage plants and the remaining insitu plants near Watchman were collected over the period of one month beginning early- to mid-July. In 2014, seeds were harvested starting July 17th from BOEHOR plants salvaged from Grotto Cove. Watchman plants were ready for collection from July 31st and early-mid September. Seeds are ready for harvest when siliques are dry, thin, and light brown to straw colored.

Seed Collection Techniques: Slide small glassine envelopes under siliques and gently rub the fruiting pod; seeds will slip out easily if they are ripe.

Plans for Propagation: This species is to be re-established in Central WRD via plug production and seed sowing; containers will range from 4-6" diameter. Early results from germination trials demonstrated that our BOEHOR seeds had a high percentage of germination (98%). The plants that arrived from the CPMC in 2016 showed that this 98% germination rate was consistent and the plugs themselves had a similarly high survival rate. The plants delivered were robust and flowered and fruited from the time they arrived on September 13, 2016 until all reproductive organs were trimmed for preparation for planting on October 12, 2016. Some of the BOEHOR plugs will be overwintered in the Ballfield for planting in 2017.

Crater Lake rockcress seeds at maturity. Photo by Melody Frederic.

Species: *Bromus carinatus* var. *carinatus* (BROCARCAR); California brome

Family: Poaceae

California brome near Rim Village. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial bunchgrass (Figure C11). Fruit is caryopsis; spikelet is strongly compressed with glumes keel-like. Florets 7-11; lemma body 12-17 mm; keel-like; awn 3-15 mm.

Phenology and Seed Ripeness: Seed heads turn from green to a reddish brown and become firm and hard as seeds ripen. Seeds are fully mature when they become straw-colored; however, seeds can be collected prior to this stage as long as they are not green.

Seed Collection Techniques: Run fingers from the bottom of the inflorescence to the top using light pressure; seeds that are mature enough will pop into pinched fingers. Try not to collect seeds that exhibit smut, but do not panic if *some* smutty material gets into your collection (as per Amy Bartow, Corvallis PMC).

Plans for Propagation: This species is to be re-established in North WRD and NE ERD seed zones and is targeted for seed collection and propagation by sowing and plug production.

Left: Inflorescence with mature seeds. Right: Mature California brome seeds. Photos by Melody Frederic.

Species: *Carex brewerii* (CARBRE); Brewer's sedge

Family: Cyperaceae

Brewer's sedge. Photo by Melody Frederic.

Life History and Seed Information: Plant is perennial with rhizomes. Perigynia 10-40 per spikelet, ascending to spreading, 4-7 mm, 2.1-4.8 mm wide, very flat, thin, golden-brown, a bristle-like axis within. Fruit 1.7-2.3 mm, 0.8-1 mm wide, << smaller than perigynium body, 3-sided.

Phenology and Seed Ripeness: Seeds are ripening when white anthers are gone and the entire inflorescence is brown. The head will feel soft as the seeds mature; at full maturity, the head will be somewhat brittle.

Seed Collection Techniques: Fully mature seeds will crumble easily into the hand or bag. However, if the head is brown but still soft, seeds still can be collected by cutting stems; collecting the heads with the stems allow seeds to continue receiving nutrients and to develop into maturity according to Corvallis PMC personnel.

Plans for Propagation: This species is to be re-established in North WRD and NW ERD. This species is targeted for seed sowing and plug production; containers will range from 4-6" diameter. This species is selected for germination trials and propagation protocol development.

Left: Brewer's sedge in flower. Right: Immature Brewer's sedge seeds with a developing perigynium. Photos by Melody Frederic.

Species: *Carex halliana* (CARHAL); Hall's sedge

Family: Cyperaceae

Hall's sedge. Photo by Melody Frederic.

Life History and Seed Information: Plant is perennial with rhizomes. Perigynia 20-40 per spikelet, 3.6-5mm, 1.7-2.3 mm wide, thick-walled, strongly many-ribbed, green to gold, beak 1-1.7 mm, teeth erect, 0.2-0.5 mm. Fruit 1.9-2.5 mm, 1.3-1.8 mm wide.

Phenology and Seed Ripeness: Seeds are fully ripe when the female spikes, which occur below the male spike(s), turn brown; however, per Corvallis PMC personnel, seeds can be collected while seeds are still green (see techniques for collecting below

Seed Collection Techniques: Seeds can be collected before they turn brown as long they no longer contain any liquid and are solid or doughy. Check by cutting open or crushing a seed. Collect the inflorescences along with the stem and leaves so that nutrients continue to be provided to the seeds as they develop. Using this technique, seeds were collected during mid-August in 2014. Because of the amount of vegetation collected with the seeds, plants were spread out in large bins to allow for adequate drying and then dried plants were stored in paper bags.

Notes from 2015/2016: It was observed by the Corvallis PMC that if there is a high level of predation on the seeds, this significantly limited the germination rate. Suggested counters were to collect as much as reasonably practicable and freeze the collections for 48 hours after they have been thoroughly dried. Propagation was attempted for CARHAL for Northeast East Rim Drive in 2016. Information on propagation techniques was scarce but only eight cones were delivered to CRLA. Therefore it can be postulated that CARHAL is difficult to propagate, especially for a sedge.

Plans for Propagation: This species is to be re-established in South WRD and NE ERD. This species is targeted for plug production; plug containers will range from 4-6" diameter. This species is selected for germination trials and propagation protocol development.

Hall's sedge spikelets with mature perigynia. Photo by Melody Frederic.

Species: *Carex pachycarpa* (CARPAC); Many-ribbed sedge

Family: Cyperaceae

Many-ribbed sedge. Photo by Melody Frederic.

Life History and Seed Information: Plant is perennial and cespitose. Inflorescence is dense, triangular, and sometimes elongate. Perigynium appressed-ascending, 3.5-6.3 mm, 1.5-2.5 mm wide, body ovate to wide-ovate, planoconvex, green to light brown, flat margin including wing 0.2-0.5 mm wide, veins on back > 8, on front generally > 3, beak tip cylindric and entire for < 0.4 mm, gold. Fruit 1.7-2.7 mm, 1.1-1.7 mm side, stalk 0.4-0.8 mm.

Identification Tips: *C. straminiformis* looks similar to *C. pachycarpa*. However, *C. straminiformis* perigynia have a broad flat "potato chip" shape while *C. pachycarpa* perigynia are not broad and are planoconvex (flat on one side and rounded on the other).

Phenology and Seed Ripeness: Seeds are ready for collecting when the inflorescence turns brown and brittle.

Seed Collection Techniques: Seeds are easily collected by rubbing the inflorescence and allowing the seeds to fall in the hand or bag. According to Corvallis PMC personnel, seeds also can be collected while seeds are maturing if stems are cut with the seed heads to provide nutrients that allow seeds to continue maturing.

Plans for Propagation: This species is to be re-established in South WRD and is targeted for seed sowing and plug production; containers will range from 4-6" diameter. This species is selected for germination trials and propagation protocol development.

Left: CARPAC spikelets with mature perigynia. Right: CARPAC perignynia. Photos by Melody Frederic.

Species: *Castilleja applegatei* var. *applegatei* (CASAPPAPP); Applegate's paintbrush

Family: Orobanchaceae

Applegate's paintbrush. Photo by Jen Beck.

Life History and Seed Information: Plant is a perennial forb. Fruit is a loculicidal capsule, +/- ovoid, and +/- assymmetrical. Seeds are brownish, attached to capsule walls at base, 1 – 1.5 mm.

Phenology and Seed Ripeness: Seeds ripen, starting lower on the inflorescence, shortly after calyx bracts senesce; ripeness can be detected by capsules turning pale brown and becoming dry and papery. This species is only collected in Central WRD, and is found in rocky habitats, making collection sparse and sometimes dangerous. Seeds are ready to collect when you hear them rattle around inside the capsule and the capsule septa easily dehisce when prompted by your thumbnail. According to Amy Bartow of the Corvallis PMC, some *Castilleja* plants have capsules that never open, so collectors need to keep watch. She suggests collecting stems when one can capture the best yield.

Seed Collection Techniques: Since seeds "jump" out of capsules and are readily lost, collecting generally is easier by clipping or cutting the entire inflorescence. In 2014, this species was highly susceptible to insect predation, especially within the capsules where seeds are developing, but was far less predated upon in 2015.

Plans for Propagation: This species is to be re-established at only one site (the Union Peak grade site 143+20 to 146+02 in Central WRD) and is targeted for seed collection and propagation by sowing and plug production.

Applegate's paintbrush in bloom and in seed. Photos by Melody Frederic.

Species: *Castilleja arachnoidea* (CASARA); Cobwebby paintbrush

Family: Orobanchaceae

Cobwebby paintbrush along West Rim Drive. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial forb. Fruit is loculicidal capsule, +/- ovoid, and +/- asymmetrical, 8-12 mm. Seeds are brownish, attached to capsule walls at base, +/- 1 mm.

Phenology and Seed Ripeness: Seeds ripen shortly after calyx bracts senesce; ripeness can be detected by capsules turning pale brown and becoming dry and papery. In 2014, seeds were ready for collection in mid-September. Seeds are ready to collect when you hear them rattle around inside the capsule and the capsule septa easily dehisce when prompted by your thumbnail.

Seed Collection Techniques: Since seeds "jump" out of capsules and are readily lost, collecting generally is easier by clipping or cutting the entire inflorescence. However, in 2014 and 2016 we found this species is highly susceptible to insect predation, especially within the capsules where seeds are developing. Therefore, we recommend collecting only the fully mature seeds as this will avoid infecting other seed collections in our drying facility. Only collect seeds from capsules that have no insect holes.

Plans for Propagation: This species is to be re-established in NW ERD and is targeted for plug production; containers will range from 4-6" diameter.

Immature cobwebby paintbrush fruits and seeds with inflorescence. Photo by Melody Frederic.

Species: *Elymus elymoides* ssp. *elymoides* (ELYELYELY); Squirreltail

Family: Poaceae

Squirreltail. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial bunchgrass. Fruit is a caryopsis. Inflorescence has 2 spikelets per node; spikelet 12-20 mm. Glumes 35-85 mm, lowest floret generally sterile. Fertile florets 1+, lemma awn 25-75 mm.

Phenology and Seed Ripeness: Seeds are ready to collect when the inflorescences bush out like a squirrel's tail and exhibit a pale, almost white, straw color. This species exhibited the widest range of availability than any other species collected for the RDRR project. It tended to become collectable sooner and peak sooner in the South WRD and NE ERD seed zones than in the other three zones.

Seed Collection Techniques We use two methods to collect ELYELY. For the first method, grab a hold of the inflorescence and pull (mature seed head should break off easily into your hand). With the second method, use scissors or clippers to cut stems of inflorescences that are beginning to fluff open like a squirrel's tail, and maturing of seed heads should continue due to the attached stem. Because of the bushy inflorescences, use a large grocery-size bag. Occasionally tamp down the seeds by pushing down with your hand enclosed in a small lunch-size bag; this will prevent the seeds from sticking to your hand and sleeve while packing down the seeds. It is also difficult to collect ELYELY seed on a windy day, as seed heads are easily carried by the wind.

Plans for Propagation: This species is to be re-established in all five seed zones and is targeted for seed collection and propagation by sowing and plug production.

Mature squirreltail seeds with inflorescence. Photos by Melody Frederic.

Species: *Ericameria greenei* (ERIGRE); Greene's goldenweed

Family: Asteraceae

Greene's goldenweed. Photos by Melody Frederic.

Life History and Seed Information: Plant is a perennial shrub. Fruit is an achene, 6-7 mm, narrowly oblong, +/- glabrous to densely appressed-soft-hairy; pappus = disk corollas, white to light brown.

Identification Tips: *E. greenei* and *E. bloomerii* look similar. However, *E. greenei* has stems and leaves that are stipitate-glandular while *E. bloomeri* has stems and leaves that are glabrous, tomentose, or gland-dotted (sessile or in pits).

Phenology and Seed Ripeness: Seeds are ready to collect after flowers fade, pappus appears, and achenes turn from green to brown.

Seed Collection Techniques: Seeds were collected using two methods: pulling pappus with achene attached from seed heads and placing in bags; and clipping seeded heads from the parent plant and placing them in bags. This plant is highly susceptible to insect infestation, which is why we place collections in the freezer for a minimum of 24 hours immediately post-collection. This is one of the latest-maturing species on the RDRR species list.

Plans for Propagation: This species is to be re-established in South WRD, Central WRD, and North WRD and is targeted in these three seed zones for propagation by seed sowing and plug production.

Species: *Ericameria nauseosa* var. *speciosa* (ERINAUSPE); Showy rubber rabbitbrush

Family: Asteraceae

Showy rubber rabbitbrush. Photos by Melody Frederic.

Life History and Seed Information: Plant is a perennial shrub. Fruit is an achene, 3-8 mm, generally hairy; pappus = disk corollas, white to light brown.

Identification Tips: This species is collected only in the NE ERD seed zone. A similar species, *Ericamerica greenei*, occurs interspersed with *E. nauseosa* in some areas within this seed zone. *E. nauseosa* can be distinguished by its narrow silver-green leaves; *E. greenei* has leaves that are slightly broader and a deeper green color. *E. nauseosa* is a taller shrub (2-28 dm); *E. greenei* is a shorter shrub (1-3 dm).

Phenology and Seed Ripeness: Seeds are ready to collect after flowers fade, pappus appears, and achenes turn from green to brown.

Seed Collection Techniques: Seeds were collected either by pulling pappus with achene attached from seed heads and placing in bags, or by clipping seeding tips and placing in bags.

Plans for Propagation: This species is to be re-established in NE ERD and is targeted for propagation by seed sowing and plant plugs.

Species: *Eriogonum marifolium* var. *marifolium* (ERIMARMAR); Sierra eriogonum

Family: Polygonaceae

Left: Male Sierra eriogonum plant. Center: Female Sierra eriogonum plant. Right: Closeup of Sierra eriogonum inflorescence containing mature seeds. Photos by Melody Frederic.

Life History and Seed Information: Plant is a dioecious perennial subshrub. Fruit is an achene, 3.5-5 mm, with slightly hairy tip, brown to black. Seed is single and attached to ovary wall at a single point. Male and female plants have different flowers: male perianth is 1-2 mm and dull yellow; female perianth is 4-7 mm and bright yellow to red.

Identification Tips: *Eriogonum marifolium var. marifolium* and *Eriogonum umbellatum* var. *polyanthum* are similar in appearance. However, *Eriogonum umbellatum* var. *polyanthum* is bisexual while *Eriogonum marifolium var. marifolium* is dioecious.

Phenology and Seed Ripeness: As flowers continue to develop, female flowers tend to inflate and begin to show a reddish hue to their yellow petals while the male plants remain completely yellow. Seeds are ready to harvest once flowers turn a pale orange or red color and feel dry and papery; a mature seed will be black.

Seed Collection Techniques: Crumble flower heads directly into paper bags or cup your hand at the base of the umbel and gently pull up to have seeds fall into your hand.

Plans for Propagation: This species is to be re-established in South WRD, Central WRD, North WRD, and in 2015 was added to NW ERD. ERIMAR is targeted for seed sowing and plug production.

Mature Sierra eriogonum seed. Photo by Melody Frederic.

Species: *Eriogonum pyrolifolium* var. *coryphaeum* (ERIPYRCOR); Alpine buckwheat

Family: Polygonaceae

Alpine buckwheat plant. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial forb from a thick woody caudex. Fruit is an achene, 4-5 mm with a hairy tip, brown to black. Seed is single and attached to ovary wall at a single point.

Identification Tips: Two variations of *Eriogonum pyrolifolium* occur in CRLA: var. *coryphaeum* and var. *pyrolifolium.* ERIPYRCOR has leaf blades densely lanate to tomentose abaxially, mostly glabrous adaxially; ERIPYRPYR has leaf blades glabrous on both surfaces.

Phenology and Seed Ripeness: Flowers are initially white, with pollenated flowers turning red as fruit develops. A small lump can be felt where fruits are developing. Seeds are ready to harvest once flowers have dried and turned a pale salmon color and fruits are hard. At that point, flower heads should be easily pulled off the plant with no resistance. In many locations in 2015, it was sometimes difficult to find that perfect, papery set of flowers – they were either still fresh-feeling, or spent. In those situations, check the hardness of the seed, then use the clipping method (see below). PMC staff noticed signs of seed predation in our 2014 collection.

Seed Collection Techniques: We collected ERICOR in two ways. Usually, we gently pull flower heads and place into paper bags. Occasionally, when we thought the seed heads could benefit from a little further development, we clip the entire inflorescence stem.

Plans for Propagation: This species is to be re-established Central WRD, North WRD, and NW ERD. This species is targeted for seed sowing and plug production. Preliminary results of PMC germination trials demonstrated that ERIPYR seeds had 83% germination in the warm growth chamber after 90 days of cold, moist stratification.

Left, Center: Developing Alpine buckwheat seed and inflorescence. Right: Alpine buckwheat plant at seed maturity stage with dry, salmon-colored petals. Photos by Melody Frederic.

Species: *Holodiscus microphyllus* var. *glabrescens* (HOLMICGLA); Bush ocean spray

Family: Rosaceae

Bush ocean spray. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial shrub. Fruits are achenes, 5, 1-1.5 mm, hairy, often with sessile glands (Figure C32).

Phenology and Seed Ripeness: Seeds are maturing when inflorescences turn brown, look bristly, and feel dry to the touch.

Seed Collection Techniques: Crumble dry achenes into a paper bag; also, the entire inflorescence can be collected.

Plans for Propagation: This species is to be re-established in South WRD and is targeted for propagation by seed into plugs for planting.

Left: Inflorescences turning dry, bristly, and brown. Right: Each flower head contains 5 hairy achenes. Photos by Melody Frederic.

Species: *Juncus parryi* (JUNPAR); Parry's rush

Family: Juncaceae

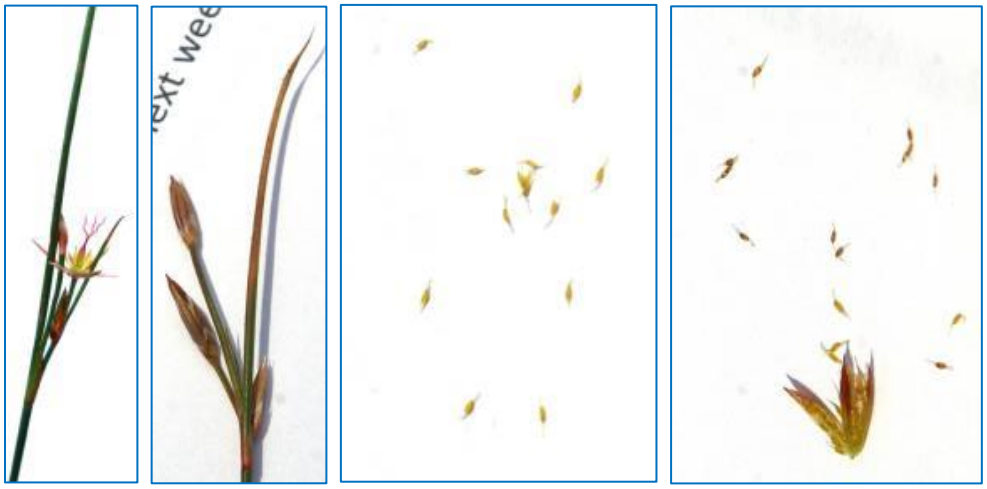
Parry's rush. Photo by Melody Frederic.

Life History and Seed Information: Plant is perennial and densely caespitose. Fruit is a loculicidal capsule, gen > perianth, 3-angled; tip acute. Seeds are 2 mm, ovate; appendages > seed body.

Phenology and Seed Ripeness: Capsule has to be cut or squeezed open to determine status of seeds. Unripe seeds are a sickly yellow and bend to your fingernail; ripe seeds are amber to bronze in color and crack when fingernail pressure is applied. Observations in the field suggest that if mature fruits are left too long in the field, they are subject to increased caterpillar predation.

Seed Collection Techniques: Since seeds are so small, cutting stems with capsules attached when the seeds are at or nearing maturity is the best method. The stems continue to provide nutrients, allowing seeds to reach full maturity. Place collection bags directly into freezer for a minimum of 24 hours to kill any predators. Place stems with capsules in plastic bins. Allow to dry. Seeds will drop to the bottom of the bins and can then be collected and stored in Ziplock® baggies. Seeds are so small, they appear to be reddish "dust." Checking under a scope will confirm the presence of seeds in the bin bottom.

Plans for Propagation: This species, to be re-established in NW ERD, is targeted for plug production and seed sowing.



Left: Parry's rush flower. Center Left: Inflorescence with mature seeds. Center Right: Immature Seeds. Right: Maturing seeds. Photos by Melody Frederic.

Species: *Leutkea pectinata (*LEUPEC); Partridgefoot

Family: Rosaceae

Partridgefoot. Photo by Melody Frederic.

Life History and Seed Information: Plant is perennial, +/- prostrate subshrub. Fruits are follicles, 4-6, +/- 4 mm, leathery, dehiscent along both sutures. Seeds are > 1, +/- fusiform, flat, smooth.

Phenology and Seed Ripeness: Seeds are ready to collect when capsules on stems turn a rosy-rusty color and begin to crack open.

Seed Collection Techniques: Fruits found lower on the stem will dehisce first – at that point, clip the entire stem and place in small paper sacks, as seeds are small. Try not to tip inflorescences until they are over or in the bag.

Plans for Propagation: This species is to be re-established in NW ERD and is targeted for seed sowing and plug production. Early germination trials at the PMC Corvallis revealed that LUEPEC seeds showed no signs of seed dormancy and germinated readily in warm temperatures.

Left: Mature Partridgefoot inflorescences with rusty-red color. Right: Mature seeds and capsule debris. Photos by Melody Frederic.

Species: *Lupinus andersonii* (LUPAND); Anderson's lupine

Family: Fabaceae

Anderson's lupine. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial forb. Fruit is a dehiscent, oblong legume, 2-4.5 cm, and silky. Seeds are 4-6 per pod, 4-6 mm, and mottled tan or brown.

Phenology and Seed Ripeness: Seeds are ripe when legume pods turn brown and seeds inside feel hard and solid.

Seed Collection Techniques: Once seeds ripen, their pods burst open, immediately scattering seeds out into the soil. Notes from 2014: We experimented with placing nylon stockings over developing seed pods (see photo below). We also collected developing seed pods with stems and leaves attached; these we placed in small plastic bins lined with newsprint and allowed the plant material to dry. Both techniques provided mature seeds; however, bag placement had a more successful yield but was more labor intensive as they required exact location information and a return trip to retrieve the bags and seeds. Notes from 2015: Given the low seed production and collection from 2014, we were keen to capitalize on the higher pod production year in 2015. We used the nylon sock collection method for approximately 65 plants. We collected some inflorescences on the early-side, just in case, as in 2014, developing pods just disappeared on their way to maturity. For 4 weeks, we collected LUPAND inflorescences on the last day of the work week, so that we would not lose many ripe pods over the hot, dry weekends. LUPAND is our most difficult species to collect from given its elusive nature. Entire inflorescence stems were clipped and bagged. Around the time of LUPAND collection, we had several rains which made the foliage so moist, that mold developed. For this reason, we started sending our LUPAND collections within a week after collection to the Corvallis PMC where optimal drying conditions are easily achieved. Notes from 2016***:*** Given the predation observed we decided to freeze all of the biomatter collected for 48 hours after collection**.** This was done with two collections form Munson Meadow. However we recalled that freezing green foliage and seeds before it has had time to desiccate properly can damage the tissue and the remaining two collections were not frozen. The predations appeared to be mainly due to ants. In 2017, if possibly, it should be determined if the freezing affected the germination rate of the seeds.

Plans for Propagation: This species is to be re-established in South WRD by seed sowing and plug production, and in 2015 was added to North WRD.

Left: Bagged Anderson's lupine inflorescence for capturing seeds. Right: Mature seeds. Photos by Melody Frederic.

Species: *Lupinus lepidus* var. *lobbii* (LUPLEPLOB); Prostrate lupine

Family: Fabaceae

Prostrate lupine. Photo by Melody Frederic.

Life History and Seed Information: Plant is an herbaceous, matted perennial forb. Fruit is a dehiscent, somewhat oblong legume, 1-2 cm, and hairy. Seeds are 2-4 per pod, 2-4 mm, and +/- tan or green to brown.

Identification information: Two varieties of *Lupinus lepidus* occur in CRLA: var. *lobbii* and var. *sellulus.* The inflorescence of LUPLEPLOB is more or less head-like, 2-8 cm, and the plant is < 1 dm in height. LUPLEPSEL has more elongate inflorescences, 4.5-11 cm, and the plant is 1.2-3.5 dm in height.

Phenology and Seed Ripeness: Seeds are ripe when legume pods turn light brown, and seeds inside feel hard and solid.

Seed Collection Techniques: After seeds ripen, their pods burst open, scattering seeds out into the soil. Because this species of lupine held on to its seed longer and had a longer blooming period than LUPAND, we did not need to use the individual bags to capture seeds. We collected developing seed pods, sometimes with attached stems, then spread our collections in small plastic bins to dry.

Plans for Propagation: This species is to be re-established in NW ERD, NE ERD and was added to North WRD in 2015. LUPLEPLOB is targeted for seed collection and propagation by sowing and plug production. Early results from PMC seed germination trials showed that scarified LUPLEPLOB seeds had high percentages of germination (96% - 100%) without cold stratification in both the warm treatments and cooler room temperature treatments.

Mature prostrate lupine seeds. Photo by Melody Frederic.

Species: *Penstemon davidsonii* var. *davidsonii* (PENDAVDAV); Davidson's penstemon

Family: Plantaginaceae

Davidson's penstemon. Photo by Melody Frederic.

Life History and Seed Information: Plant is a mat-forming perennial subshrub. Fruit is a septicidal capsule. Seeds are many and small.

Phenology and Seed Ripeness: Seeds are mature when capsules become dry and turn from green to a rich chestnut brown color; seeds can be heard "rattling" inside capsules. Capsules open from the top and tend to hold on to their seed, weather permitting, for a several weeks. Collection should not begin until capsules begin to open.

Seed Collection Techniques: Seeds within dehisced capsules can be poured into the hand or bag. However, because the seeds are so small, it is recommended to collect the entire inflorescence stem just prior to capsules dehiscing.

Plans for Propagation: This species is to be re-established in Central WRD and North WRD and is targeted for plug production and seed sowing. This species is currently undergoing germination trials at the PMC in Corvallis.

Mature Davidson's penstemon seed capsules. Photo by Melody Frederic.

Species: *Phacelia hastata* ssp. *compacta* (PHAHASCOM); Compact phacelia

Family: Boraginaceae

Compact phacelia. Photo by Melody Frederic.

Life History and Seed Information: Plant is a perennial forb. Fruit is a loculicidal capsule, 2-4 mm, ovoid, stiff-hairy. Seed are 1-3, 1.5-2.5 mm, pitted in vertical rows.

Phenology and Seed Ripeness: Seeds are ready to harvest when they change from white to black. Seed heads become brown, prickly, dry, and pull easily from the plant

Seed Collection Techniques: Collect the entire seed head only when it can be easily pulled away from the plant. Gloves are recommended when collecting seed.

Plans for Propagation: This species is to be re-established in NE ERD by seed sowing. 2014 collections of PHAHAS showed signs of seed predation.

Mature (black) and immature (beige-brown) compact phacelia seeds with inflorescence and capsule debris. Photo by Melody Frederic.

Species: *Phlox diffusa* (PHLDIF); Spreading phlox

Family: Polemoniaceae

Spreading phlox. Photo by Melody Frederic.

Life History and Seed Information: Plant is a matted, perennial forb. Fruit is a capsule; occurs singularly at the terminal end of stems and contains one seed.

Phenology and Seed Ripeness: While developing, seeds are "hidden" inside fruit capsules at the end of stems. Seeds are ripe when the terminal stem leaves open to reveal the seed capsule, which has turned hard, and starts changing from green to light brown.

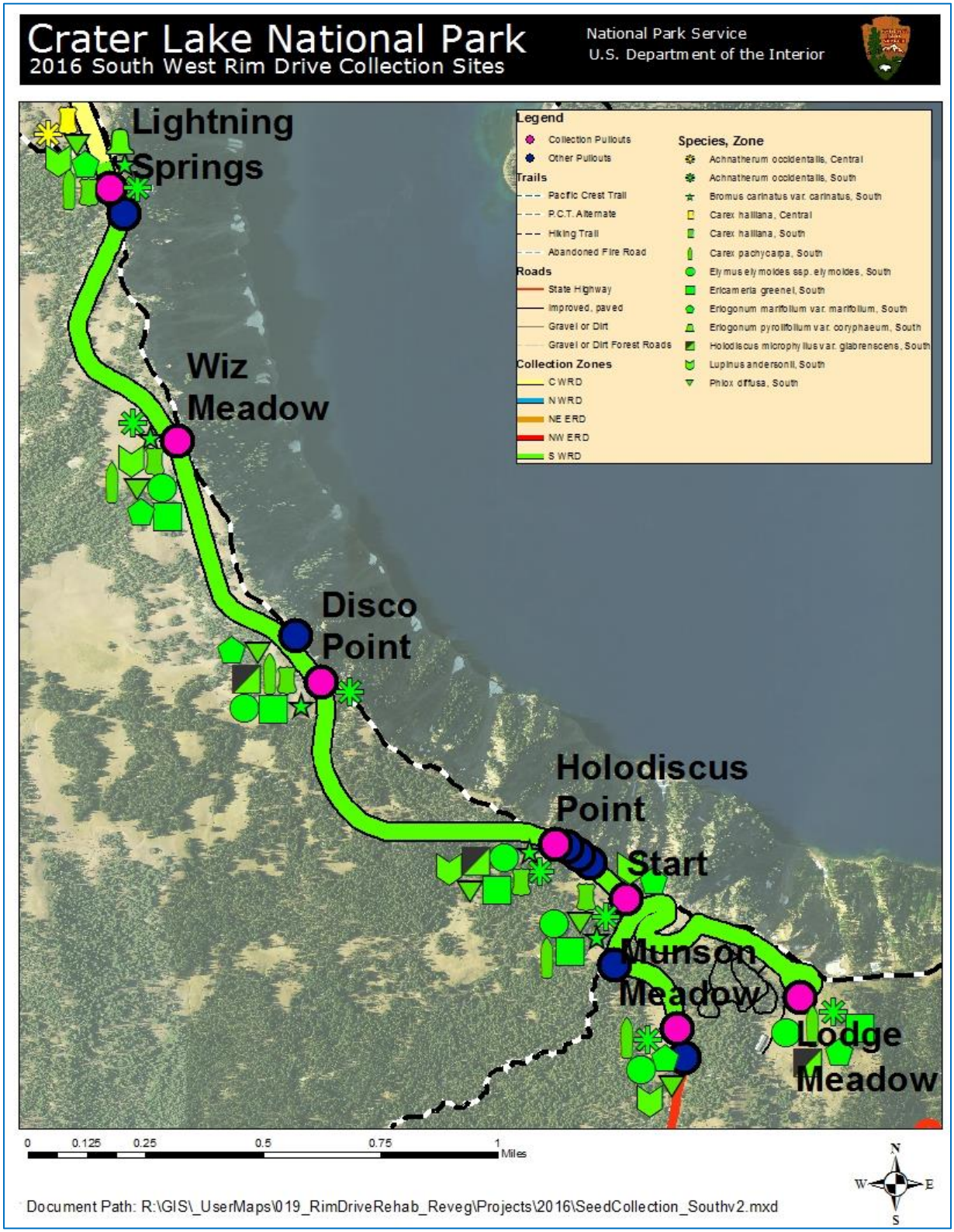
Seed Collection Techniques: Collect the seeds when they are no longer "hidden" but are perched at the terminal end of stems. Ripe or near-ripe seeds tend to be "jumpy;" therefore, gently secure the seed capsule between your thumb and index finger before pinching the seed capsule from the terminal end of the stem.

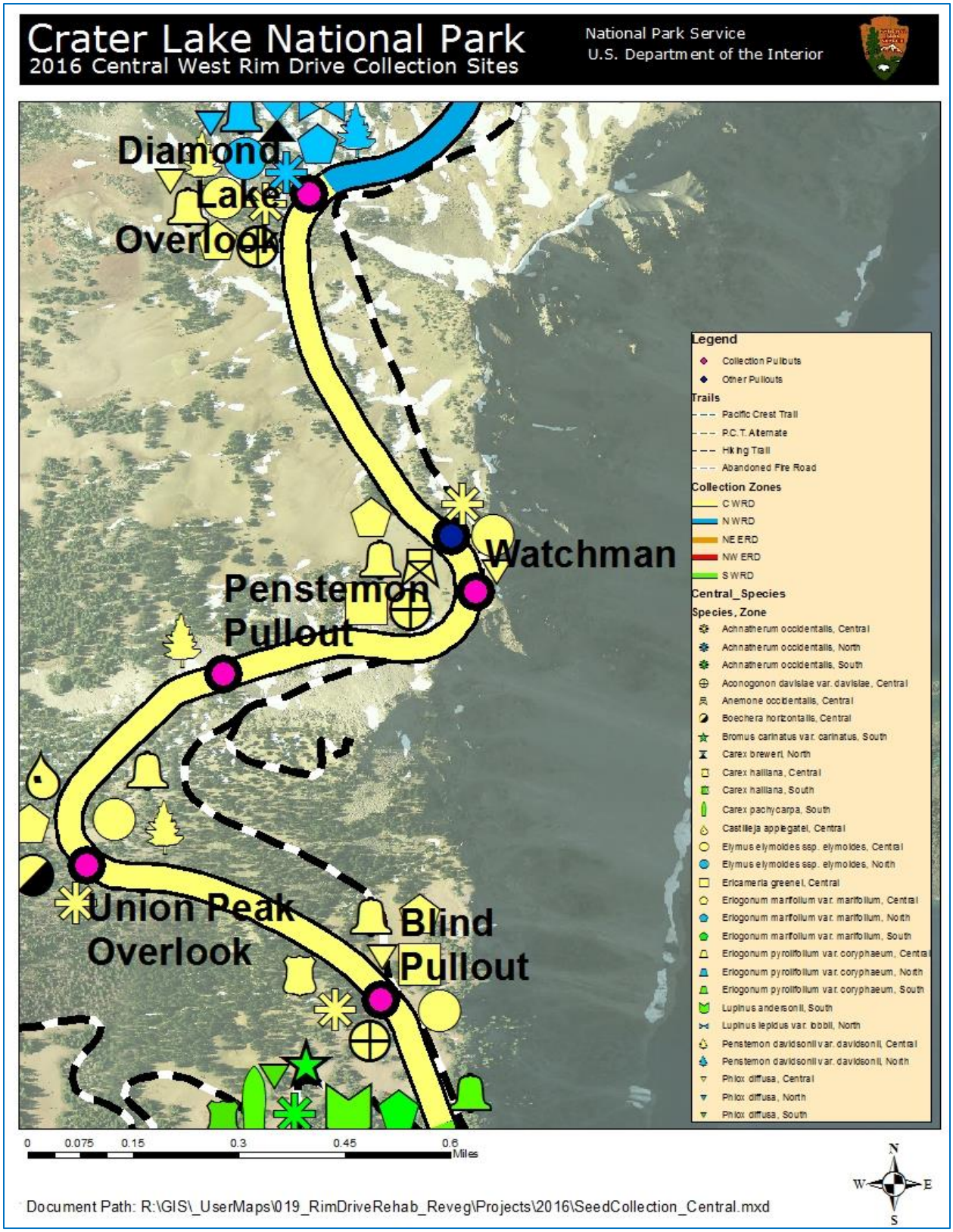
Additional information: This is a time-consuming plant from which to collect; however, it is an important component in the South and Central WRD seed zones and a minor component in the North WRD zone. It was collected in small numbers in 2014 and will need to be focused on in 2015. While the collection in 2016 exceeded the numbers collected in 2015 and 2014 the numbers are still less than prescribed and further collection is advised. Because the seeds mature over time on any given plant and within any given population, it is recommended to return on a regular basis throughout the season to areas where good PHLDIF coverage occurs.

Plans for Propagation: This species is to be re-established in South WRD, Central WRD, and North WRD and is targeted for propagation by sowing and plug production.

Left: Mature speading phlox capsules. Right: Mature spreading phlox seeds. Photos by Melody Frederic.

Appendix C – Seed Collection Maps




Crater Lake National Park
2016 Central West Rim Drive Collection Sites
National Park Service
U.S. Department of the Interior
Diamond Lake Overlook
Watchman
Penstemon Pullout
Union Peak Overlook
Blind Pullout
Legend
Collection Pullouts
Other Pullouts
Trails
Pacific Crest Trail
P.C.T. Alternate
Hiking Trail
Abandoned Fire Road
Collection Zones
C WRD
N WRD
NE ERD
NW ERD
S WRD
Central_Species
Species, Zone
Achnatherum occidentalis, Central
Achnatherum occidentalis, North
Achnatherum occidentalis, South
Aconogonon davisiae var. davisiae, Central
Anemone occidentalis, Central
Boechera horizontalis, Central
Bromus carinatus var. carinatus, South
Carex breweri, North
Carex halliana, Central
Carex halliana, South
Carex pachycarpa, South
Castilleja applegatei, Central
Elymus elymoides ssp. elymoides, Central
Elymus elymoides ssp. elymoides, North
Ericameria greenei, Central
Eriogonum marifolium var. marifolium, Central
Eriogonum marifolium var. marifolium, North
Eriogonum marifolium var. marifolium, South
Eriogonum pyrolifolium var. coryphaeum, Central
Eriogonum pyrolifolium var. coryphaeum, North
Eriogonum pyrolifolium var. coryphaeum, South
Lupinus andersonii, South
Lupinus lepidus var. lobbii, North
Penstemon davidsonii var. davidsonii, Central
Penstemon davidsonii var. davidsonii, North
Phlox diffusa, Central
Phlox diffusa, North
Phlox diffusa, South
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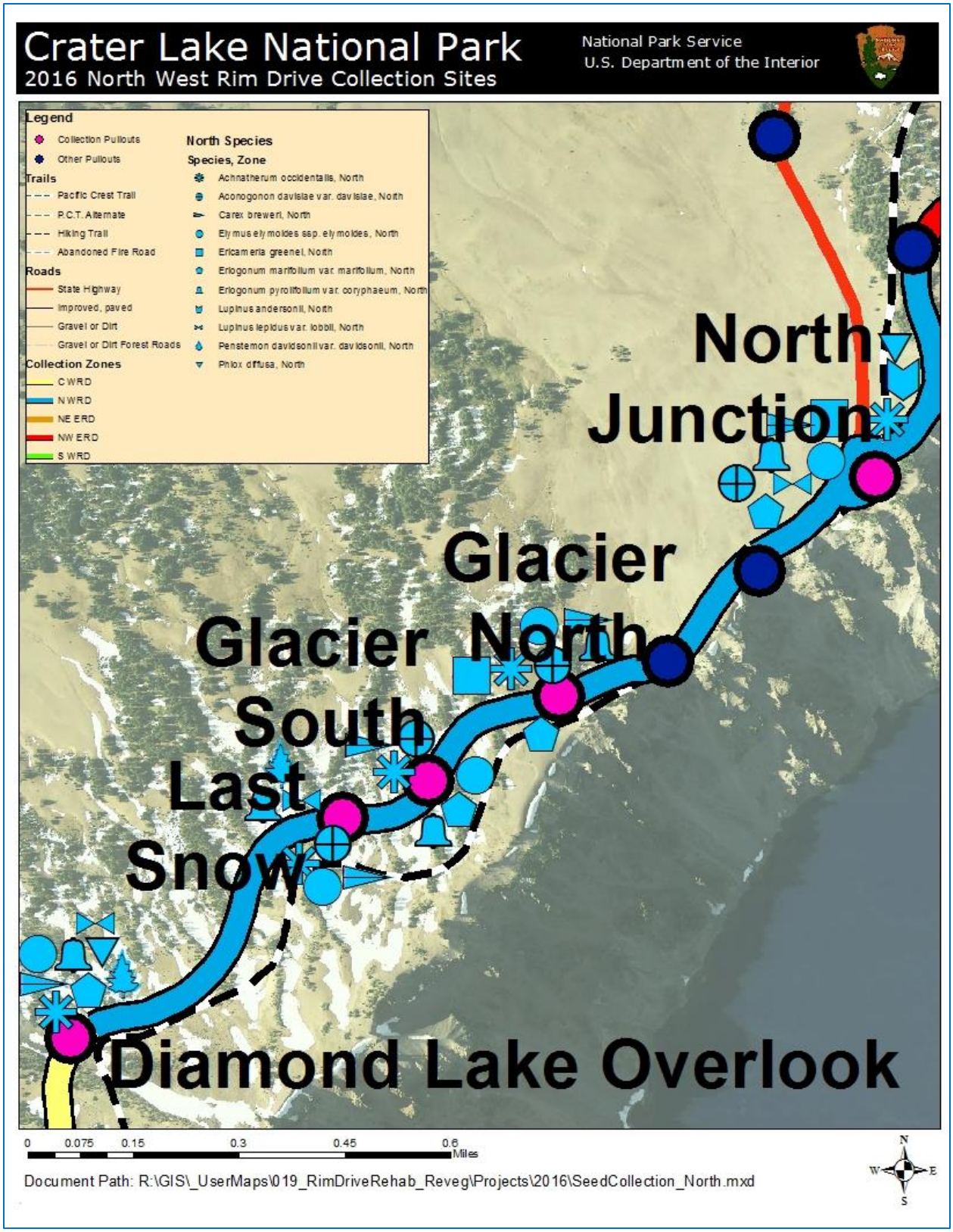
Crater Lake National Park
2016 North West Rim Drive Collection Sites
National Park Service
U.S. Department of the Interior
Legend
Collection Pullouts
Other Pullouts
Trails
Pacific Crest Trail
P.C.T. Alternate
Hiking Trail
Abandoned Fire Road
Roads
State Highway
Improved, paved
Gravel or Dirt
Gravel or Dirt Forest Roads
Collection Zones
C WRD
N WRD
NE ERD
NW ERD
S WRD
North Species
Species, Zone
Achnatherum occidentalis, North
Aconogonon davisiae var. davisiae, North
Carex breweri, North
Elymus elymoides ssp. elymoides, North
Ericameria greenei, North
Eriogonum marifolium var. marifolium, North
Eriogonum pyrolifolium var. coryphaeum, North
Lupinus andersonii, North
Lupinus lepidus var. lobbii, North
Penstemon davidsonii var. davidsonii, North
Phlox diffusa, North
North Junction
Glacier
Glacier North
South
Last
Snow
Diamond Lake Overlook
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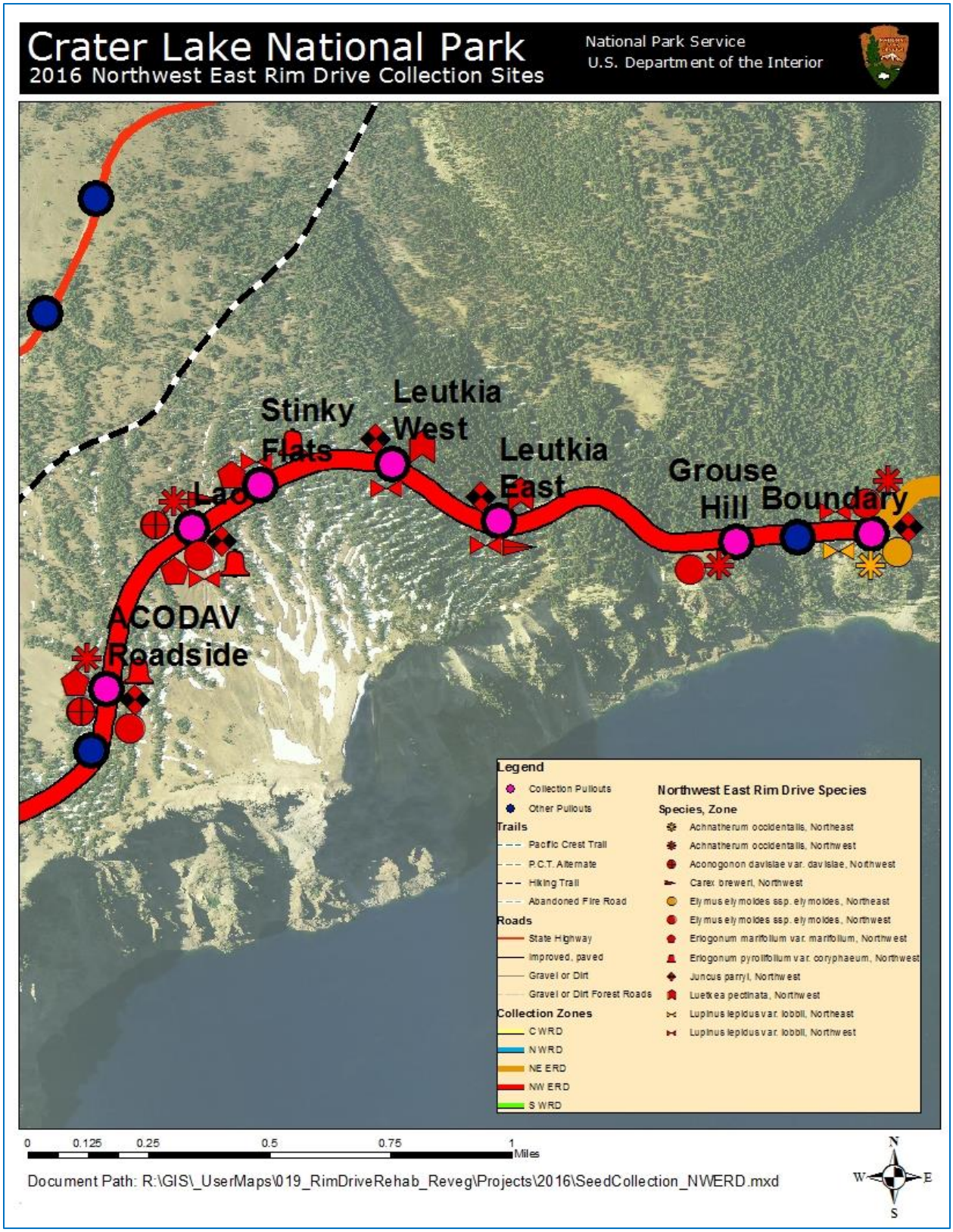
Crater Lake National Park
2016 Northwest East Rim Drive Collection Sites
National Park Service
U.S. Department of the Interior
Stinky Flats
Leutkia West
Leutkia East
Grouse Hill
Boundary
ACODAV Roadside
Legend
Collection Pullouts
Other Pullouts
Trails
Pacific Crest Trail
P.C.T. Alternate
Hiking Trail
Abandoned Fire Road
Roads
State Highway
Improved, paved
Gravel or Dirt
Gravel or Dirt Forest Roads
Collection Zones
CWRD
NWRD
NE ERD
NW ERD
S WRD
Northwest East Rim Drive Species
Species, Zone
Achnatherum occidentalis, Northeast
Achnatherum occidentalis, Northwest
Aconogonon davisiae var. davisiae, Northwest
Carex breweri, Northwest
Elymus elymoides ssp. elymoides, Northeast
Elymus elymoides ssp. elymoides, Northwest
Eriogonum marifolium var. marifolium, Northwest
Eriogonum pyrolifolium var. coryphaeum, Northwest
Juncus parryi, Northwest
Luetkea pectinata, Northwest
Lupinus lepidus var. lobbii, Northeast
Lupinus lepidus var. lobbii, Northwest
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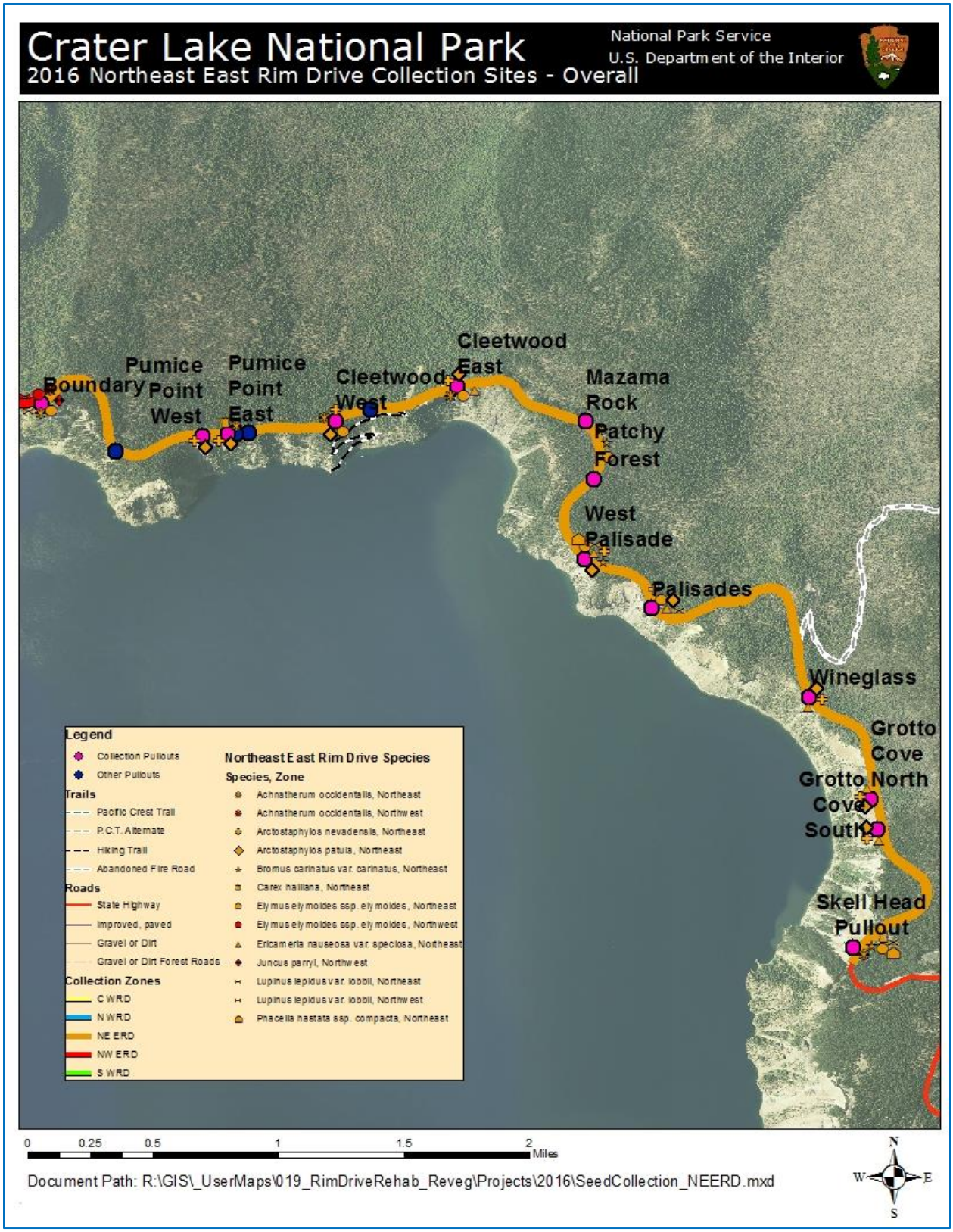
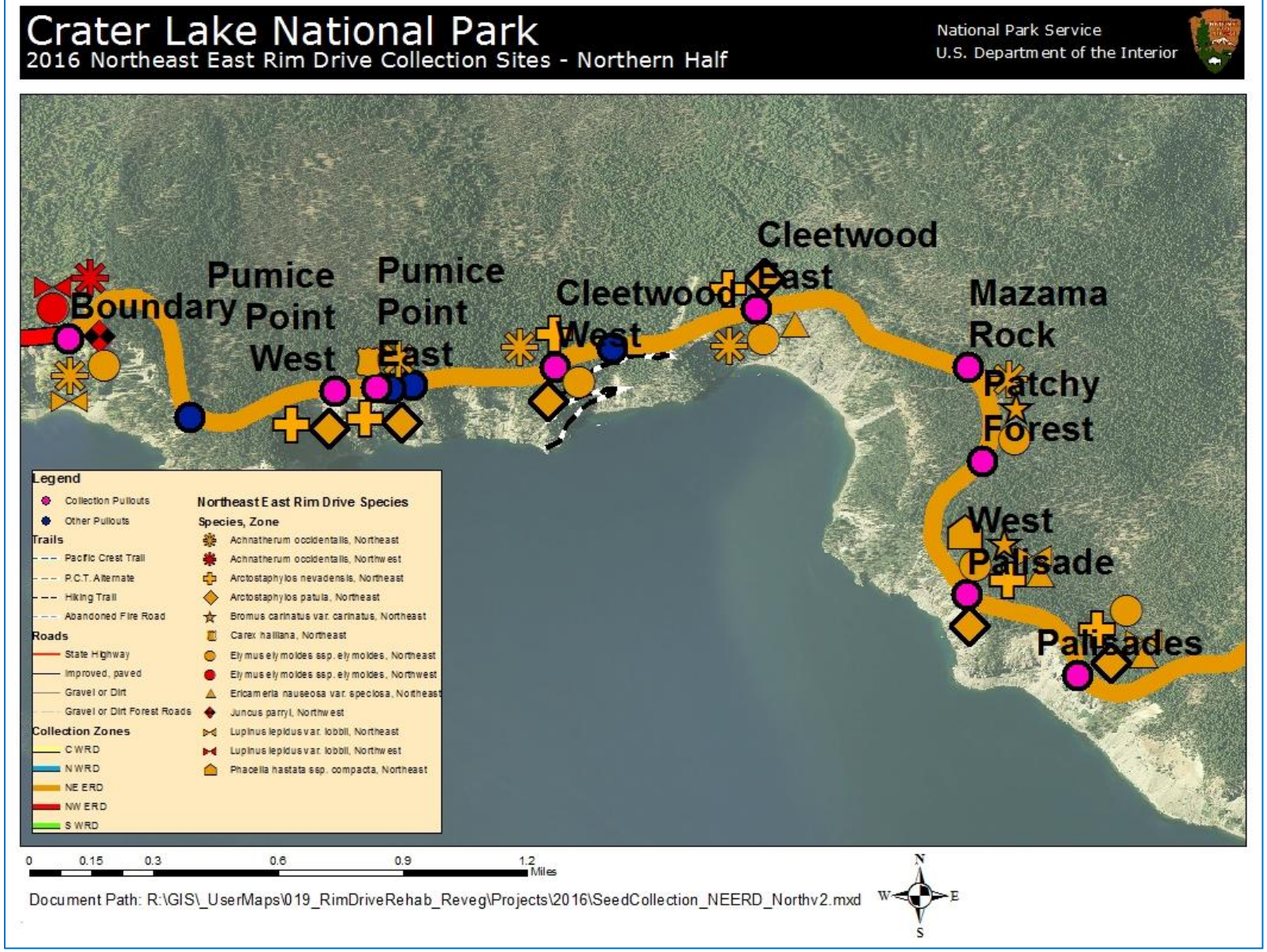
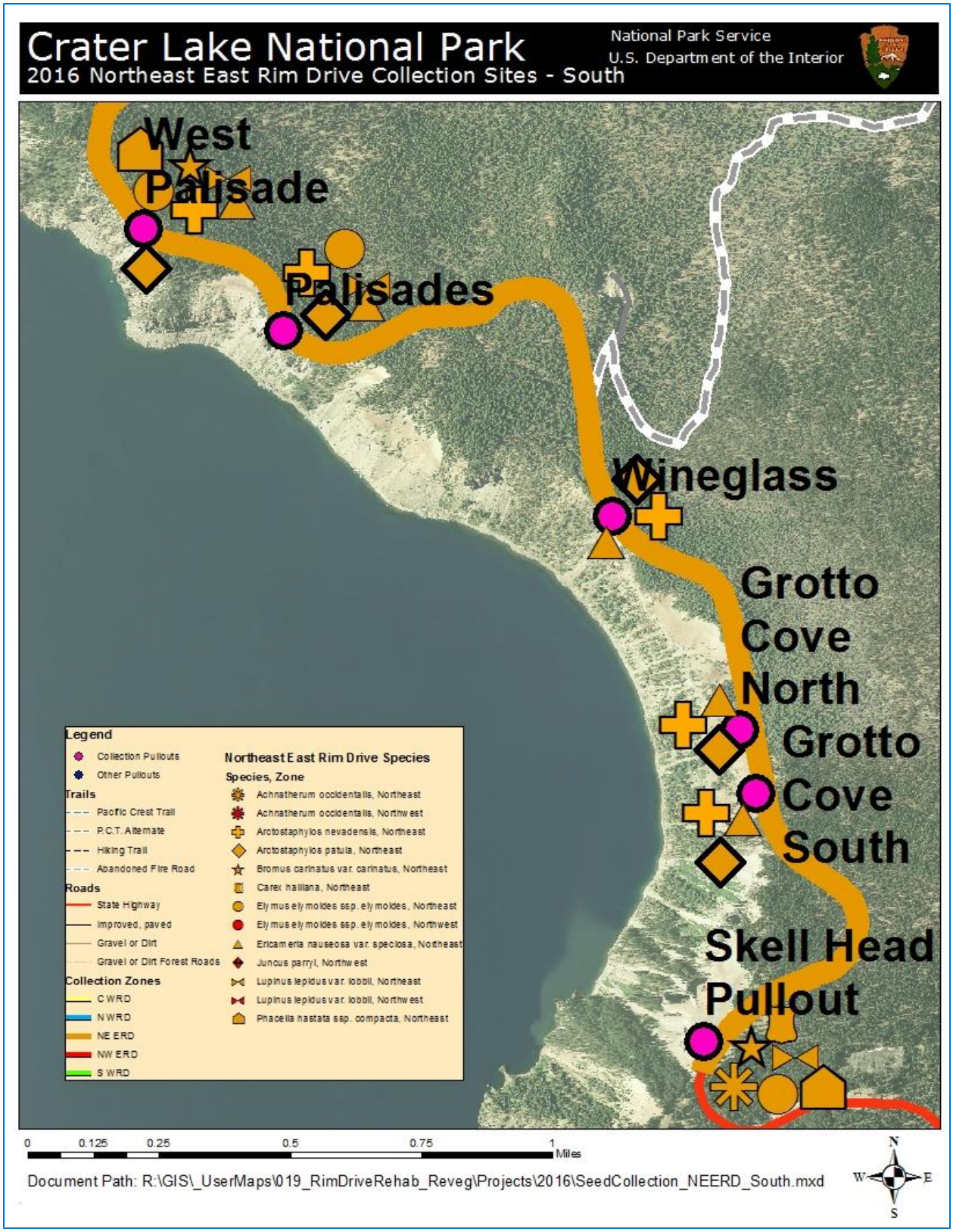

Crater Lake National Park
2016 Northeast East Rim Drive Collection Sites - Overall
National Park Service
U.S. Department of the Interior
Boundary
Pumice Point West
Pumice Point East
Cleetwood West
Cleetwood East
Mazama Rock
Patchy Forest
West Palisade
Palisades
Wineglass
Grotto Cove
Grotto North Cove
South
Skell Head Pullout
Legend
Collection Pullouts
Other Pullouts
Trails
Pacific Crest Trail
P.C.T. Alternate
Hiking Trail
Abandoned Fire Road
Roads
State Highway
Improved, paved
Gravel or Dirt
Gravel or Dirt Forest Roads
Collection Zones
CWRD
NWRD
NEERD
NWERD
SWRD
Northeast East Rim Drive Species
Species, Zone
Achnatherum occidentalis, Northeast
Achnatherum occidentalis, Northwest
Arctostaphylos nevadensis, Northeast
Arctostaphylos patula, Northeast
Bromus carinatus var. carinatus, Northeast
Carex halliana, Northeast
Elymus elymoides ssp. elymoides, Northeast
Elymus elymoides ssp. elymoides, Northwest
Ericameria nauseosa var. speciosa, Northeast
Juncus parryi, Northwest
Lupinus lepidus var. lobbii, Northeast
Lupinus lepidus var. lobbii, Northwest
Phacelia hastata ssp. compacta, Northeast
0
0.25
0.5
1
1.5
2
Miles
Document Path: R:\GIS_UserMaps\019_RimDriveRehab_Reveg\Projects\2016\SeedCollection_NEERD.mxd
N
W
E
S


Crater Lake National Park
2016 Northeast East Rim Drive Collection Sites - Northern Half
National Park Service
U.S. Department of the Interior
Boundary
Pumice Point West
Pumice Point East
Cleetwood West
Cleetwood East
Mazama Rock
Patchy Forest
West Palisade
Palisades
Legend
Collection Pullouts
Other Pullouts
Trails
Pacific Crest Trail
P.C.T. Alternate
Hiking Trail
Abandoned Fire Road
Roads
State Highway
Improved, paved
Gravel or Dirt
Gravel or Dirt Forest Roads
Collection Zones
CWRD
NWRD
NEERD
NWERD
SWRD
Northeast East Rim Drive Species
Species, Zone
Achnatherum occidentalis, Northeast
Achnatherum occidentalis, Northwest
Arctostaphylos nevadensis, Northeast
Arctostaphylos patula, Northeast
Bromus carinatus var. carinatus, Northeast
Carex halliana, Northeast
Elymus elymoides ssp. elymoides, Northeast
Elymus elymoides ssp. elymoides, Northwest
Ericameria nauseosa var. speciosa, Northeast
Juncus parryi, Northwest
Lupinus lepidus var. lobbii, Northeast
Lupinus lepidus var. lobbii, Northwest
Phacelia hastata ssp. compacta, Northeast
0 0.15 0.3 0.6 0.9 1.2 Miles
Document Path: R:\GIS_UserMaps\019_RimDriveRehab_Reveg\Projects\2016\SeedCollection_NEERD_Northv2.mxd
N
W
E
S


Crater Lake National Park
2016 Northeast East Rim Drive Collection Sites - South
National Park Service
U.S. Department of the Interior
West Palisade
Palisades
Wineglass
Grotto Cove North
Grotto Cove South
Skell Head Pullout
Legend
Collection Pullouts
Other Pullouts
Trails
Pacific Crest Trail
P.C.T. Alternate
Hiking Trail
Abandoned Fire Road
Roads
State Highway
Improved, paved
Gravel or Dirt
Gravel or Dirt Forest Roads
Collection Zones
CWRD
NWRD
NEERD
NWERD
SWRD
Northeast East Rim Drive Species
Species, Zone
Achnatherum occidentalis, Northeast
Achnatherum occidentalis, Northwest
Arctostaphylos nevadensis, Northeast
Arctostaphylos patula, Northeast
Bromus carinatus var. carinatus, Northeast
Carex halliana, Northeast
Elymus elymoides ssp. elymoides, Northeast
Elymus elymoides ssp. elymoides, Northwest
Ericameria nauseosa var. speciosa, Northeast
Juncus parryi, Northwest
Lupinus lepidus var. lobbii, Northeast
Lupinus lepidus var. lobbii, Northwest
Phacelia hastata ssp. compacta, Northeast
0 0.125 0.25 0.5 0.75 1 Miles
Document Path: R:\GIS_UserMaps\019_RimDriveRehab_Reveg\Projects\2016\SeedCollection_NEERD_South.mxd
N
W
E
S

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.

May 2017

National Park Service
U.S. Department of the Interior

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