OREGON DEPARTMENT OF AGRICULTURE

NATIVE PLANT CONSERVATION PROGRAM

Recovery-based propagation and outplanting of *Lilium occidentale*: preparation for outplanting

Year 3 (2011)

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Introduction

With spectacular crimson and golden flowers, the western lily (*Lilium occidentale*, Liliaceae) is one of the most stunning rare plants in our region (Figure 1). Unfortunately, its beauty may be underappreciated, as the species is declining and rarely seen across most of its limited range, from just south of Humboldt Bay in California to the vicinity of Coos Bay in Oregon. Along this approximately 200 mile (320 km) stretch of Pacific coastline, *L. occidentale* occurs only as far as four miles (six km) inland (USFWS 1998). Within this narrow distribution, the species is restricted to freshwater fens, bog edges, and seasonally wet areas where it grows in coastal prairie and scrub.

Figure 1. The particularly showy flower of *Lilium occidentale*; note the distinctive diagnostic green center.

Although the western lily has adapted to slight variations in site conditions within its range, the narrow habitat specificity of the species seems to have restricted both population size and overall frequency and distribution. Overharvesting from these finite populations further forced this species into rarity, and together with the limited suitable habitat, may be a serious obstacle for this species' persistence in the future. The range of *L. occidentale* overlaps several urban centers along the coast, as well as numerous small but expanding coastal communities, exposing the species to increasing levels of disturbance. Human influenced habitat loss due to ecological succession resulting from fire suppression and other land management practices that alter coastal plant communities and landscape processes also impacts this species. Habitat losses, along with critical declines in population numbers and size, prompted the Oregon Department of Agriculture Native Plant Conservation Program (ODA) to list the species as endangered; federal listing as endangered followed suit. (For more information on *L. occidentale* ecology, threats, status, and recovery planning, see USFWS 1998, USFWS 2009, Brown et al. 2012).

Plant Description

Lilium occidentale is a tall and showy member of the lily family (Liliaceae). A perennial, this true lily dies back each season to over-winter as an underground rhizomatous bulb, occasionally undergoing full year dormancy (USFWS 2009). Each spring, the slender stems emerge, reaching heights between 60 and 170 cm. The unbranched stem produces scattered, dark green, narrowly oblanceolate leaves (6 - 22 cm long by 0.5 - 2.5 cm wide) that may be whorled in the central portion of the stem. The nodding flowers, up to ten per plant (though typically fewer), are born on very long pedicels. The tepals (4 - 5 cm long) curve back about half their length, exposing the remarkable inner surface, which transitions from crimson and deep red near the tip (distal portion) to orange, yellow, greenish-yellow, or sometimes green near the base (proximally). This lighter colored portion, also dappled with maroon spots, comes to a point near the midline of the tepal, imbuing the center of the corolla with what appears to be a bright star shape when viewed from the open end of the flower. Along with the red flower color and star-shaped yellow or greenish flower center, the non-spreading, exserted stamens are one of the species' most diagnostic characters. Although most young plants only produce a single above-ground leaf, some plants that remain vegetative will produce an elongated stem and several leaves. Fully mature plants may be seen flowering between mid-June to August (Skinner 2002). Although most members of *Lilium* are obligate outcrossers, *L. occidentale* is self-fertile (Imper 1997).

There are 22 species and nine subspecies of *Lilium* in North America (Skinner 2002), and several other *Lilium* species co-occur with *L. occidentale.* Despite superficial similarities, *L. occidentale* is easily distinguished from its congeners by habitat specificity, presence of a true bulb, flower morphology, and non-spreading stamens. Marked morphological differences between some Oregon and California populations of *L. occidentale* have incited discussion of the potential merits of subdividing the species (Skinner 2002). The proposed "California form" tends to be taller, have wider leaves that are more often whorled, and produces more flowers. The "Oregon form" is typically shorter, with fewer flowers and narrower leaves that are less often whorled. However, these morphologically distinct forms appear to be correlated with habitat types rather than genotypes, with the California form

occupying coastal prairie and scrub, and the Oregon form preferring *Sphagnum* bogs (Skinner 2002). The morphological variability of the species is further complicated by the potential for hybridization between *L. occidentale* and *L. columbianum* (tiger lily) or *L. pardalinum* ssp. *vollmeri* (Vollmer's lily) (Skinner 2002).

Project Overview

In accordance with the recovery plan specifications, ODA developed a five year project focusing on cultivation and outplanting to help meet the criteria for the downlisting of *L. occidentale*. This project focuses on seven principal populations on Oregon public land that are identified in the USFWS five-year review as prime candidates for expansion and augmentation (USFWS 2009). These "principal populations", as listed in the USFWS five-year review, approximate biologically-meaningful populations, and are comprised of occurrences that have been grouped for management and recovery planning purposes. ODA's work encompasses augmentation of three principal populations in Recovery Area 1 (Hauser Bog, Bastendorff Bog, and Shore Acres State Park); two in Recovery Area 2 (Floras Lake State Park and Cape Blanco State Park), and two in Recovery Area 4 (Highway and Powerline populations at Harris Beach State Park) (Figure 2).

The first year of work focused on collecting seed for use in cultivating transplant stock. This phase of work involved the development of a seed collection protocol, the identification of appropriate populations from which to collect seeds, and development of cultivation protocols in cooperation with the Natural Resources Conservation Service Corvallis Plant Materials Center (NRCS). The second year of work included the selection of potential transplant areas for augmenting the selected principal populations with cultivated stock, as well as additional seed collections, continued coordination of cultivation efforts, and initial planning for habitat enhancement at project sites. The third year of work, completed in 2011 and the subject of this report, focused on developing outplanting protocols and establishing plots in preparation for transplanting. This third phase also included continued coordination of habitat enhancement and additional seed collections. The remaining two years of project work will include transplanting of the cultivated stock and monitoring to determine outplanting success. Monitoring transplant survival will provide valuable information to

guide future transplanting efforts. We expect this work to set the stage for subsequent large scale outplantings of *L. occidentale*, in order to reach the ultimate goal of recovery and eventual downlisting.

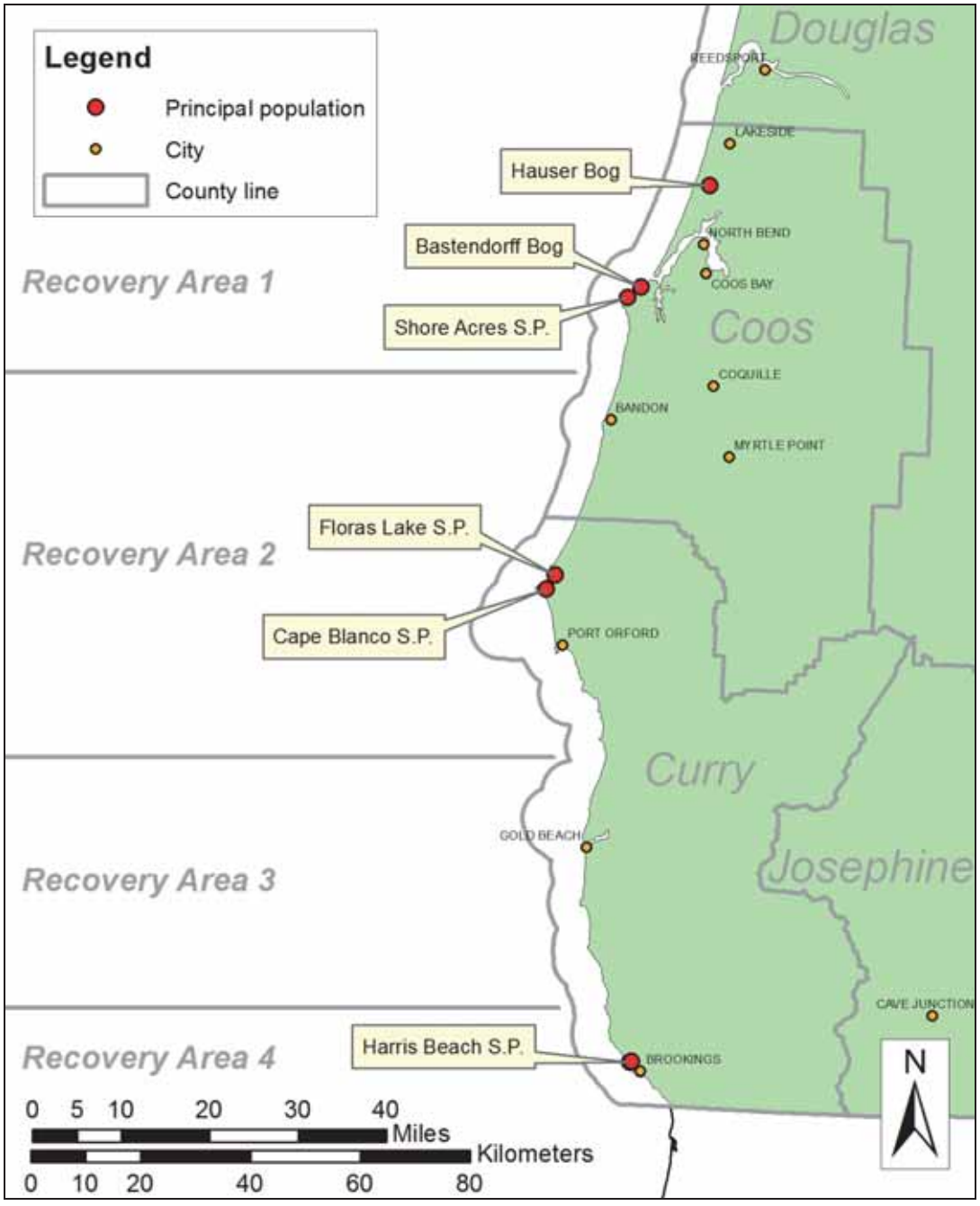

Figure 2. The seven principal populations selected for augmentation occur at six sites spanning all three occupied recovery areas in Oregon (the Highway site and Powerline site populations are both located at Harris Beach State Park). GPS data for specific locations is available in electronic format from ODA.

Seed Collection

To help increase the genetic diversity of cultivated stocks and reduce potential for inbreeding depression in future transplanted populations, wild seed was periodically collected from each targeted principal population. Successive collections increase the number of genotypes present in cultivated stock and help incorporate temporally varying diversity. A cohort of plants collected from multiple years potentially represents a genetic complex that may flourish within the varying conditions a created population may encounter (Brown and Briggs 1991).

In 2011, seed collection efforts focused on the seven populations previously selected for seed collection and augmentation (Figure 2; Table 1). Each population was visited during August, while plants were still in flower and could be positively identified. Mesh bags were affixed around developing seed capsules to prevent the loss of seed from capsules that dehisced before we revisited to collect mature seed (Figure 3). Although up to ten developing capsules were bagged at each population, some of these were browsed by herbivores or insects, and others didn't fully develop, resulting in a final collection of fewer capsules than were initially bagged. A total of 22 capsules were collected from 22 individual plants at six of the seven selected populations (Table 1); no mature capsules remained for collection at Cape Blanco. (For more information on seed collections and protocols see Brown et al. 2012).

Seeds collected in 2011 were scheduled to be provided to the NRCS staff managing the cultivation of the western lily transplants. This new seed was collected in part to supplement the transplants already under cultivation. However, using seeds provided by ODA in 2009 and 2010, NRCS staff had already achieved their goal for the number of plants needed. Since the seeds were not needed by NRCS, the entire accession was submitted to the Rae Selling Berry Seed Bank and Plant Conservation Program at Portland State University (RSBSB) for long term storage.

Table 1. Principal populations visited in 2011 and associated seed capsule collections.

Principal population	Recovery area	Site ownership[a]	Number of plants collected from in 2011	Number of capsules collected in 2011
Hauser Bog	1	ODOT	6	6
Bastendorff Bog	1	OPRD	5	5
Shore Acres State Park	1	OPRD	1	1
Floras Lake State Park	2	OPRD	3	3
Harris Beach State Park (Highway site)	4	ODOT / OPRD	4	4
Harris Beach State Park (Powerline site)	4	OPRD	3	3
Total capsules collected in 2011				**22**
Estimated seed yield from collections in 2011[b]				**2,525**

[a] ODOT = Oregon Department of Transportation
OPRD = Oregon Parks & Recreation Department
[b] estimated seed yield based on capsule to seed ratio in the 2009 accession

Figure 3. Mesh bags affixed around developing seed capsules ensured no seed was lost as the capsules matured and dehisced before collection.

Habitat Enhancement and Planting Area Selection

Habitat enhancement needs at the principal populations were evaluated in 2010 by staff from Oregon Department of Transportation (ODOT), Oregon Parks and Recreation Department (OPRD), USFWS, and ODA, and plans to complete the necessary work were finalized in 2011. Habitat enhancement, completed by ODOT, OPRD and ODA, involved the removal of shrubs (and some trees) in and around areas already occupied by western lilies, as well as some potential transplant sites. To avoid damaging plants during the growing season, on-site work was conducted during the winter of 2011, when lilies were dormant.

At Hauser Bog, vegetation and shrubs around the main bog and adjacent southern pond area were cleared, and most of the debris was removed from the site (Figures 4 and 5). Dense brush was removed at Bastendorff Bog to reconnect disjunct patches of western lilies, and encroaching conifers were girdled (Figure 6). At Shore Acres State Park, the northern sinkhole site was cleared of all vegetation by hand (Figure 7), while encroaching trees and trailside vegetation at the trail junction site were cut and chipped. Vegetation in western lily habitat along trails at Floras Lake State Park was mowed to reduce competition (Figure 8), and gorse infestations in the vicinity of occupied areas were treated and removed. Tree removal at Cape Blanco State Park targeted small trees (less than 15 feet tall) that were establishing in and around occupied western lily habitat. At the Harris Beach State Park Highway site, trees and shrubs within the bog, and on the edge of the fenced habitat area, were cut and removed (Figure 9). In October of 2013, the Harris Beach State Park Powerline site was cleared of all vegetation down to the ground level (Figure 10).

Planting areas at the seven principal populations were selected in conjunction with habitat enhancement planning (Figure 11). Priority areas were identified in and around the matrix of existing plants to fully utilize suitable habitat. Currently and previously occupied habitat was used as a reference for identifying suitable planting areas. Potential planting areas that differed noticeably from occupied areas in vegetation composition, topography, and hydrology were avoided. Native vegetation communities indicated places that were too low-lying and wet for planting, and areas that were higher and drier than occupied habitat. Planting in low elevation areas comprised of mud, sphagnum, and pure *Carex obnupta*

(slough sedge) stands was avoided due to previous poor outplanting results in this type of habitat in California (Imper, USFWS, Arcata, California, personal communication).

Figure 4. Prior to habitat enhancement at Hauser Bog, western lilies (visible in the foreground) were growing amongst dense vegetation.

Figure 5. Vegetation at Hauser Bog was removed from the main bog area (shown here) and adjacent southern pond area to enhance habitat for existing western lilies while improving conditions for the upcoming outplanting.

To more easily keep track of transplants in the matrix of suitable and unsuitable habitat, boundaries of large planting areas were marked out, but only suitable portions will be planted. A transect, running the length of the planting area, serves as the primary axis on which planted and unplanted plots are arranged. Planted plots can be tracked according to the side of the transect on which they are planted and their distance from the start of the transect. Plots are one meter square and align with whole meter segments of the transect. The endpoints of these transects were temporarily marked with pin flags and location information was collected using a GPS. Transect endpoints will be permanently marked with PVC posts at the time of planting.

Some planting areas were demarcated in currently unoccupied habitat adjacent to known occurrences. OPRD plans to monitor the response of existing *L. occidentale* populations to the habitat treatments, expecting to see an increase in plant size and number in currently occupied areas, and possibly in historically occupied areas as well. Keeping the transplants separated from extant populations, even by a short distance, will reduce interference between the two groups and prevent confusion during monitoring. Final planting area selections will be made from preselected areas once the cultivated bulb yield is determined.

Figure 6. At Bastendorff Bog, large conifers growing in previously cleared habitat were girdled (as shown in the background) and dense brush was removed.

Figure 7. At Shore Acres State Park, the northern sinkhole site was manually cleared of vegetation down to ground level.

Figure 8. Mowing was used to enhance western lily habitat along the trails at Floras Lake State Park.

Figure 9. The Highway site at Harris Beach State Park was overgrown (at left) prior to vegetation removal that took place during the winter of 2011 (at right).

Figure 10. The Powerline site at Harris Beach State Park was eventually mowed during the late fall of 2013.

Transplanting and Monitoring Protocols

In cooperation with USFWS, protocols for transplanting *L. occidentale* were developed. NRCS staff will harvest the bulbs (after all above-ground vegetation has died back) and pack them in plastic bags with moistened perlite for transport to the planting sites. The bulbs will

be kept cool, moist, and out of direct sunlight (in a cooler) during transport. Outplanting is tentatively planned for early November 2012 to coincide with the onset of the wet season.

In selected planting plots, transplant density will range from approximately 5-10 plants per meter square depending on site conditions. To avoid crowding, plants will not be planted closer than 10 cm to one another. Planting microsites may be cleared of residual debris from habitat enhancement, and additional pruning of surrounding vegetation may take place to allow for adequate access to soil for planting and unobstructed space for emergence. Tools for digging the planting holes include a dibble stick, a narrow tree plug shovel, a soil corer, and a bulb planter; any combination of them may be used depending on the size of bulbs and number of roots in the soil. The following are specific planting instructions to maximize success:

- Always situate the bulb roots down.
- Plant bulbs approximately 2-3 cm diameter at approximately 10 cm (4 inches) depth.
- Plant bulbs larger than 2-3 cm at approximately 15 cm (6 inches) depth.
- Never plant shallower than 1 cm deep.

Monitoring of the initial outplanting is planned for the early spring and summer of 2013. The number of emergent transplants will be counted and their life stage will be recorded as a single vegetative leaf, a mature multiple-leaved (non-flowering) plant, or a flowering reproductive plant. Herbivory, potentially a major threat to the viability of the species, will also be documented and recorded, with suspected herbivores identified when possible.

Since *L. occidentale* is preferred by herbivores both large and small (e.g. slugs, voles, rabbits, and deer), early season monitoring soon after plant emergence will be important to accurately measure emergence (as a surrogate for survival) before herbivory renders above-ground portions of plants undetectable. Monitoring during the flowering period will provide information on the reproductive performance of the transplants and allow for detection of late-emerging plants. Comparing early and late season monitoring will quantify how many emergent plants survived throughout the season and how many were impacted by herbivory.

Figure 11. At all sites, including Cape Blanco State Park (pictured here), planting areas were selected in conjunction with finalizing plans for habitat enhancement. Sherri Laier, a Natural Resource Specialist with OPRD (at right), explains to ODA staff that many of the spruce (*Picea sitchensis*) trees surrounding this potential planting area will be removed during habitat enhancement efforts.

Cultivation

At the start of the project (in 2009), USFWS contracted with NRCS for the cultivation of *L. occidentale* plants from seed to be collected by ODA. ODA assisted and consulted with NRCS during the development of their cultivation facilities and protocols (Figure 12). Successful techniques developed by ODA for the cultivation of another rare lily, *Fritillaria gentneri*, were shared with NRCS, and the need for a shade structure during the initial cultivation of seedlings was discussed. ODA provided NRCS with 66 seed capsules in November 2009 and an additional 48 capsules in October 2010. These capsules contained an estimated total of 10,000 or more seeds. As previously mentioned, NRCS staff did not ultimately need the seed collected in 2011 in order to meet their target number of cultivated plants, and this seed was provided to RSBSB. The cultivation of bulbs for transplanting by NRCS, together with ODA's collaborative efforts, is a model of interagency cooperation for western lily recovery. The details and results of cultivation and bulb production will be reported by NRCS when that information becomes available.

Summary of Project Accomplishments in 2011

- Collected additional seeds from previously selected sites, yielding 22 seed capsules from 22 individual plants (Table 1). NRCS did not need the seed from the 2011 accession, so the entire accession was submitted to RSBSB for long-term storage.
- Coordinated with ODOT, OPRD, and USFWS to restore and enhance western lily habitat, including the proposed reintroduction/augmentation sites.
- Coordinated with ODOT, OPRD, and USFWS staff to demarcate the suitable habitat selected for outplanting at target sites, and collect associated GPS location information.
- Continued to support and advise the cultivation program contracted to NRCS by USFWS.
- In coordination with USFWS, developed specific protocols for transplanting the lily bulbs grown by NRCS, and devised a monitoring plan for evaluating success of the transplanting.

Figure 12. With assistance and consultation from ODA, NRCS met production goals for western lily transplant cultivation in 2011. Photo courtesy of NRCS Corvallis Plant Materials Center staff.

Summary and Discussion

More so now than ever before, the western lily is confronted with a wide range of threats; taken together these threats have led to the species' precipitous decline. At the time of listing in 1994, one third of the known populations had been lost. Since then, at least six more populations have been extirpated. Faced with inhospitable conditions and uncertainty of survival at many sites throughout its range, western lily can benefit from both on-site and off-site conservation efforts. Preserving plant materials in protected and controlled environments, either as seeds or living vegetation, can be a safety measure for preventing extinction (Maunder et al. 2004). However, protecting and conserving extant populations, while augmenting and creating new ones, will most efficiently move the endangered western lily toward recovery and de-listing.

Seed collected during 2009 and 2010 provided propagules for cultivating transplants, while seed collected in 2011 was submitted to the RSBSB for long-term storage. The seed accessions were collected from across *L. occidentale*'s range along the Oregon coast, covering seven populations at six sites, and spanning three recovery areas. Our seed accessions represent local diversity, and this diversity will be present in the cultivated transplants. The genetic makeup of founding transplants should be similar to that of the locally adapted natural populations (Guerrant 1992, Friar et al. 2001, McGlaughlin et al. 2002) and our transplants will meet this criterion. With ongoing support and advice from ODA, the cultivation of *L. occidentale* plants by NRCS continues as a critical aspect of this project. Returning these transplants to the wild will enhance the viability of *L. occidentale* populations, and the species as a whole, helping secure the longevity of this floral gem as a component of Oregon's native flora.

In preparation for final stages of the project, ODA coordinated with partner agencies for on-site conservation efforts to improve habitat at natural *L. occidentale* population sites. Periodic brush clearing at the principal populations benefits existing plants and prepares the sites for upcoming reintroductions and augmentation. During the winter of 2011, habitat enhancement (e.g. brush and debris removal) was completed at most of the high quality occupied areas. Additional habitat enhancement took place during early spring of 2012, and

the late fall of 2013, while the above-ground portions of the western lilies were absent to avoid damaging them.

During 2011, specific planting areas were selected and marked within or near each of the seven project populations. In cooperation with USFWS, biologically appropriate planting protocols were developed. Monitoring plans were also devised to evaluate the establishment, reproductive performance, and level of herbivory experienced by the transplants.

In accordance with the recovery priority number (2) assigned to *Lilium occidentale*, the USFWS stated that "the taxon is a species that faces a high degree of threat, and has a high potential for recovery" (USFWS 2009). The upcoming reintroductions are possible because healthy *L. occidentale* populations exist and can provide propagules. That might not be the case if it were not for past and current conservation efforts, and our goal is to continue these efforts. The western lily is an eye-catching representative (Figure 13) of the unique habitats it shares with other peculiar plants, such the carnivorous California pitcherplant (*Darlingtonia californica*) and roundleaf sundew (*Drosera rotundifolia*). These habitats, along with the western lily, are under pressure. Although on-site conservation via reintroductions and augmentations will help secure the future of the western lily, there are still many fundamental questions regarding the natural history and maintenance of these populations that need to be answered. As for right now, current cultivation and upcoming reintroduction efforts, supported by a wealth of preexisting data from previous *L. occidentale* research, increase the potential for a timely recovery of western lily.

Figure 13. Western lily is a beautiful representative of the unique wetlands where it resides.

Work Proposed for 2012

- Review habitat enhancement completed by ODOT and OPRD in 2011-2012 and adapt planting plan if needed.
- Outplant ~1,200 bulbs at sites selected previously (ODOT and OPRD) using protocols developed in 2011.
- Document the locations of all planted bulbs and provide maps of all transplant plots to land managers.
- Finalize monitoring protocols and develop data collection forms.
- Continue to support and advise the cultivation program contracted to the NRCS Corvallis Plant Materials Center by USFWS and evaluate the readiness of the plants for transplanting.
- Work with ODOT and OPRD to develop and implement additional invasive species treatment in lily habitat where needed.

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