OREGON DEPARTMENT OF AGRICULTURE

NATIVE PLANT CONSERVATION PROGRAM

Recovering *Plagiobothrys hirtus* through creation of new populations in protected sites: Year 2 of 3

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for

U.S. Fish and Wildlife Service

OR-EP-2, segment 24

December 30, 2013

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Introduction

Conservation review

A Douglas County endemic, *Plagiobothrys hirtus* continues to be one of Oregon's most threatened plant species. Only about a dozen naturally occurring populations currently exist, with only four in administratively protected sites. Urbanization in the Sutherlin area continues to destroy remaining populations of this unique species, while filling and draining of adjacent wetlands has reduced the habitat quality at most remaining localities. In response to this decline, the species was listed as Endangered by Oregon Department of Agriculture (ODA) in 1989 and by U.S. Fish and Wildlife Service (USFWS) in 2000.

A reversal of this decline is dependent on not only conserving existing populations, but on reintroducing or creating populations in appropriate habitat on land that is managed for conservation. A Recovery Plan, including recommendations for creating new populations, was issued by USFWS in 2003, and successful methods for greenhouse propagation and cultivation have been developed (Amsberry and Meinke 1998). Greenhouse-grown transplants installed in 1995 and 1996 at a site managed by Oregon Department of Transportation (ODOT) have become established, and population creation efforts beginning in 1998 at Bureau of Land Management's (BLM) North Bank Habitat Management Area (NBHMA) continue to be successful (Golub-Tse et al. 2012).

In order to downlist this species to Threatened status, the Recovery Plan requires the establishment of at least nine protected reserves containing a minimum of 5,000 plants each. Each reserve must have a minimum of 1,000 square meters occupied by *P. hirtus*, and five years of monitoring data must document stable or increasing numbers of plants in seven of the nine reserves. Seventy-five percent of plants in reserves must reproduce, and reserves must be protected and managed to insure their long term survival (USFWS 2003).

Fortunately, due to ODA's nearly two decades of research on this species, information on appropriate site selection, levels of genetic variability among populations, and techniques for cultivation and outplanting are available. The prognosis for creating and managing populations is good, and significant progress has been made toward meeting the criteria for downlisting.

Plant description

Plants of *Plagiobothrys hirtus* (rough or hairy popcorn flower) are herbaceous perennials that grow up to 50-60 cm tall. Depending on environmental conditions, plants can also be considerably smaller and exhibit an annual life cycle. The upper stems of *P. hirtus* are distinctly hirsute (giving this species the "hairy" portion of its common name), and the bright green, simple linear leaves have ciliate margins. Flowering stems are spreading, with paired coiled inflorescences containing many 5-10 mm, five-petal flowers with yellow petal bases and fornices (Figure 1). Each flower can produce four tan to black colored nutlets. Due to fruit abortion or lack of pollination, calyces with fewer than four nutlets are often observed.

Figure 1. Flowers and developing seeds on a transplant at the Del Rio South site.

Plant ecology

Plants flourish as aquatics throughout the winter, emerge when wetlands dry in spring, and bloom in mid-summer. Flowers are produced in profusion, and attract many generalist pollinators; they are also self-fertile. Seed production is generally prolific, and seeds germinate readily when fall rains begin. Plants may reproduce asexually by rooting at the stem nodes, and older plants in optimally hydric habitat produce large clonal vegetation mats

before flower initiation begins. In drier sites, plants may reproduce precociously as annuals (Amsberry and Meinke 1997, Amsberry 2001).

Project description

Successful creation of new populations of *P. hirtus* is essential to recovery, and additional populations are needed to meet the downlisting requirements as specified in the Recovery Plan **(Recovery Action 1.2)**. In 2009, we proposed a three year project to create five new populations of *P. hirtus* in protected sites.

In 2009 and 2010 (Year 1; funded with Recovery Grant #13420-A-J019), using a model based on a series of environmental characteristics, we identified a list of sites suitable for reintroduction **(Recovery Actions 1.2.1.1, 1.2.1.2;** Wilson et al. 2010). We worked with land managers (BLM, Douglas County Public Works, ODOT and Oregon Parks and Recreation Department) to evaluate the administrative suitability of these sites for population creation projects, and developed plans for habitat enhancement where needed. Three new sites were selected for planting, and the two created populations at the NBHMA were designated for additional augmentation. We collected over 10,000 seeds from seven extant populations, and tested these seeds for viability. Maternal line evaluations were also completed on selected seed, and this information was used to develop cultivation and outplanting protocols that maximize genetic diversity in the created populations **(Recovery Action 1.2.2)**.

Objective

The objective of Year 2 of our study is to continue the project begun in Year 1 and work toward meeting downlisting criteria by creating new populations, and augmenting existing populations of *Plagiobothrys hirtus* **(Recovery Action 1.2.3).**

Study sites

As part of our work during Year 1 of this project, we collected seeds from seven populations and evaluated eight sites for suitability for population creation projects (Wilson et al. 2010). Based on this information, five sites were selected to receive transplants from among those evaluated (Figure 2). All sites are located in Douglas County, Oregon.

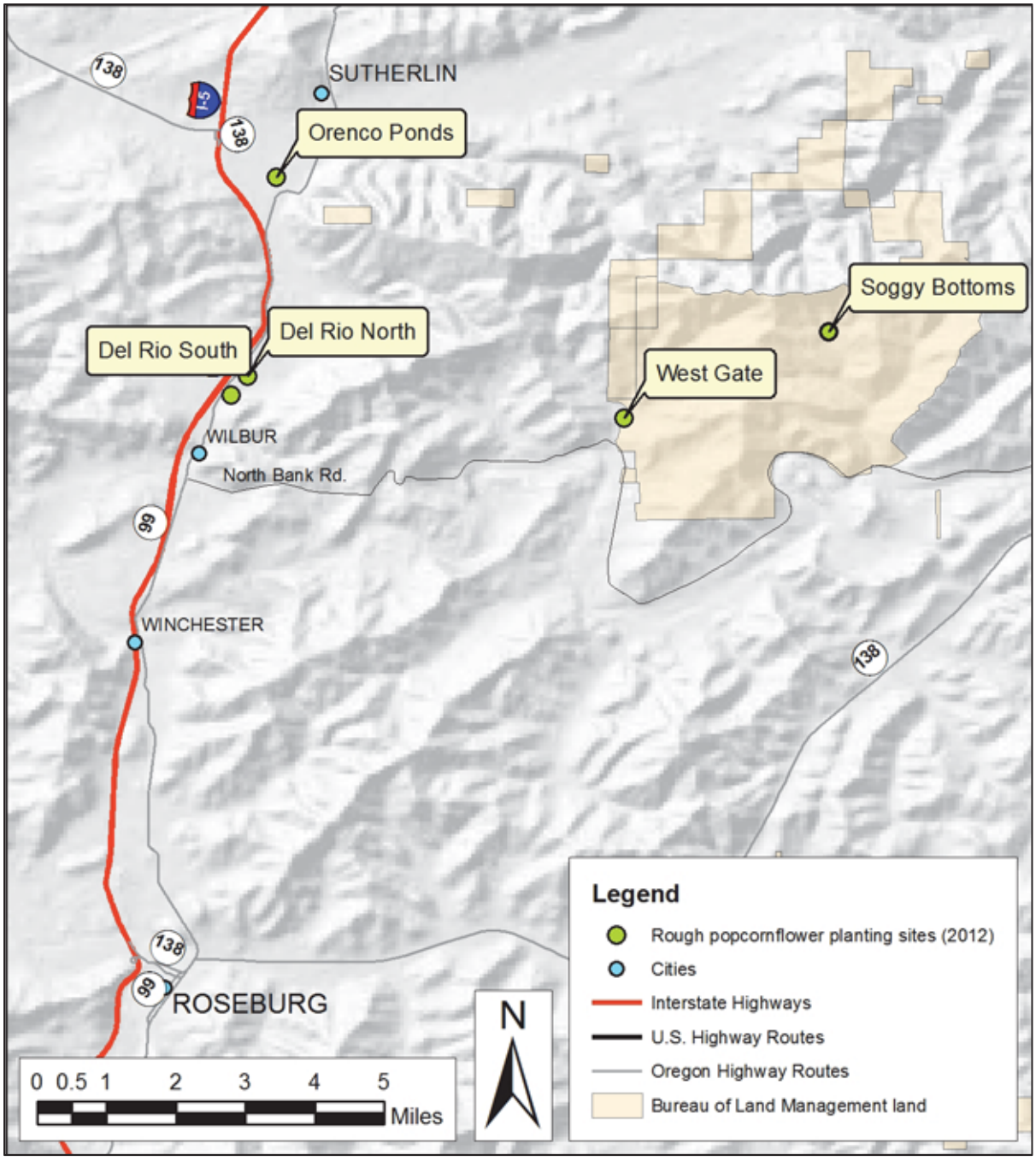

Figure 2. Location of the population creation/augmentation sites used in 2012.

Del Rio North

The Del Rio North and Del Rio South sites were purchased by ODOT as mitigation for wetland impacts associated with highway construction. These sites are managed for conservation, and supported a scattering of small populations of *P. hirtus* at the time of purchase.

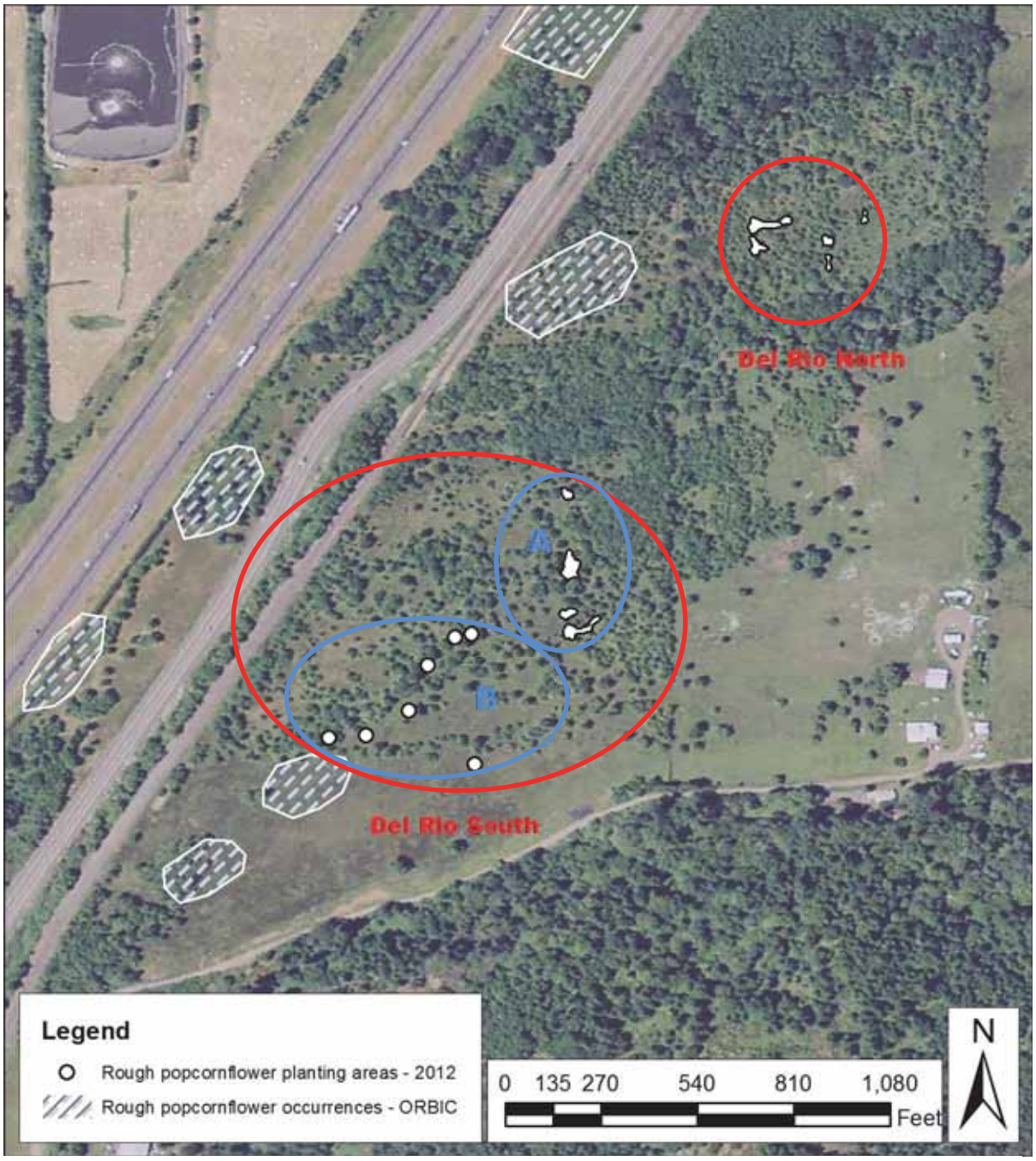

Figure 3. Location of the Del Rio North and Del Rio South sites planted in 2012.

The sites are located north and east of The Nature Conservancy's (TNC) Popcorn Swale Preserve (Figure 3) and are managed in cooperation with TNC. To enhance habitat for this species, ODOT staff removed invasive pear trees (*Pyrus communis*) that were impacting wetland hydrology and producing excess shade. ODOT biologists also routinely monitor and treat other invasive weeds, such as *Dipsacus fullonum* and *Cirsium* sp. The Del Rio North

site appears to be somewhat drier than the Del Rio South site (described below), and has more canopy cover (Figure 4). Both Del Rio sites have a good component of native vegetation, including *Beckmannia syzigachne*, *Camassia leichtlinii, Deschampsia cespitosa*, *Juncus* spp., *Limnanthes douglasii*, and a few plants of another rare species (*Perideridia erythrorhiza*). Although the water table has not been quantitatively evaluated, the hydrology of the seasonally wet pools scattered throughout the site appears to be appropriate for *P. hirtus*.

Figure 4. Planted habitat at the Del Rio North site consists of seasonally wet pools in open areas among trees. Flats of plants ready for transplanting can be seen in the front of the photograph and brush from tree removal can be seen on the right in the background.

Del Rio South

The Del Rio South site consists of a series of seasonally wet pools about ¼ mile south of the Del Rio North site (Figure 5). This site is somewhat more open and wetter than the North site, but the overall characteristics are similar, and habitat seems very suitable for *P. hirtus*.

Figure 5. At the Del Rio South site (shown here during the October 2012 planting), habitat is similar to Del Rio North, but with larger openings among the ash trees. Brush from tree removal can be seen on the right, and bright green newly planted transplants are evident in the center of the photo.

Orenco Ponds

This site, located in Sutherlin, is managed by Douglas County Public Works as a mitigation wetland (Figure 6 and 7). *Deschampsia cespitosa* was planted here at the time the wetland was created from a defunct log pond, and this species, along with native *Juncus* and *Eleocharis* spp., have established well. Unfortunately, the area is also heavily infested with exotic weeds. *Centaurea maculoasa* (List B, Noxious Weeds Quarantine; ODA 2013) occurs throughout the drier portion of the site; this weed outcompetes natives and produces allelopathic chemicals that inhibit the seed germination of native species (Ridenour and Callaway 2001). Three additional List B weeds (Scotch broom [*Cytisus scoparius*], thistles [*Cirsium* spp.] and Armenian blackberry [*Rubus* armeniacus]) occur on the periphery of the site. Within the wetland itself, both weedy and native species occur, including pennyroyal (*Mentha puligeum*), and *Downingia yina*. Transplants were planted in a series of locations

within this site, with the goal of identifying the most suitable sites for future transplant projects (Figure 6).

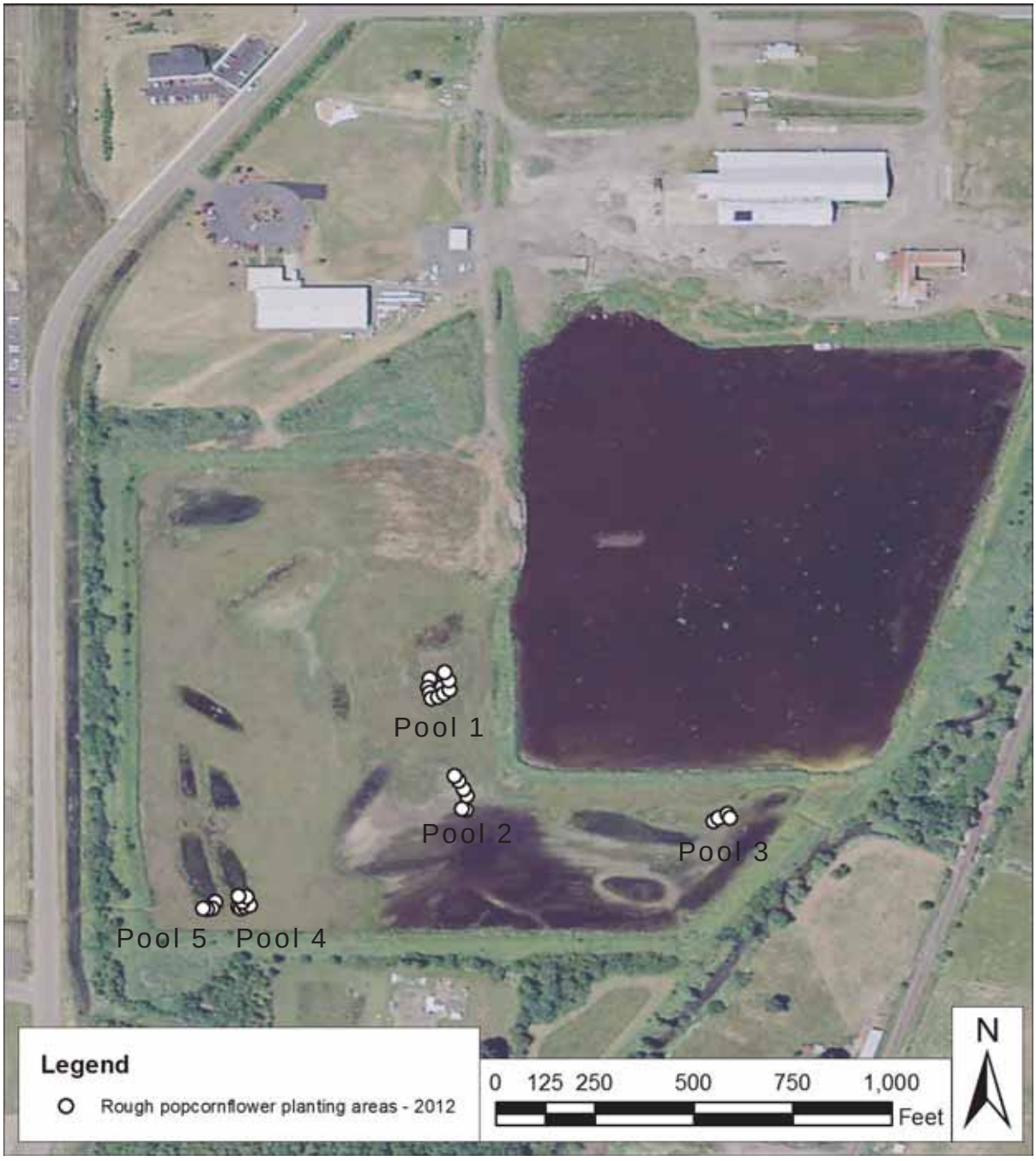

Figure 6. Location of planting pools at the Orenco Ponds site.

Figure 7. The Orenco Ponds site was reviewed by Douglas County Public Works and USFWS staff in 2010, prior to the selection of specific transplanting locations. The site's prolific population of *Deschampsia cespitosa* can be seen in the fore and middle ground, and a "hedge" of *Rubus armeniacus* in the background.

Soggy Bottoms (NWYC) - NBHMA

The NBHMA, a 6,600 acre preserve managed by BLM as habitat for the Columbian white-tailed deer, is located on Northbank Road, eight miles east of Wilbur in Douglas County, Oregon. Much of the wetland habitat within the NBHMA is similar to sites which support extant populations of *P. hirtus*, and many microsites here consist of potentially suitable habitat for this species. Naturally occurring populations of *P. hirtus* are frequently found on Conser silty clay loam soils, but can occur on other similar poorly drained soils (Natural Resources Conservation Service 1997, Soil Survey Division 2000). Although Conser soils are not present on the NBHMA, other poorly drained silty clay loam and clay soils do occur. Like sites supporting indigenous populations of *P. hirtus*, many areas within the NBHMA remain submerged in standing water throughout much of the winter and dry out completely by midsummer.

Vegetation on the NBHMA is similar to the Umpqua Valley sites where *Plagiobothrys hirtus* occurs naturally; all sites are within the Oak Savanna regional vegetation type (Franklin and Dyrness 1973) and support a similar community of native vegetation including *Beckmannia syzigachne, Deschampsia caespitosa Downingia elegans, Glyceria occidentalis, Juncus effusus, Juncus patens, Limnanthes douglasii, Sidalcea cusickii,* and *Veronica scutellata*. Like all sites with naturally occurring populations of *P. hirtus,* much of the NBHMA currently suffers from infestations of exotic weeds such as *Dipsacus sylvestris, Festuca arundinacea* and *Mentha puligeum.* Like all occupied sites, the NBHMA is within the Oregon Koeppen climate classification (Visher 1954); elevation in much of the NBHMA is within the 330-750 ft. range reported for valley *P. hirtus* sites (Oregon Natural Heritage Information Center 2008). Within the NBHMA, populations of *P. hirtus* were created at four sites: Westgate and Soggy Bottoms (1998/1999), Powerline (2002), and NWYC (2006/2007).

Although several sites that appear to be ideal for creating new populations within the NBHMA were identified during Year 1 of this project (Wilson et al. 2010), BLM review and authorization for planting in these areas was not completed at the scheduled 2012 planting dates. Because transplants grown from seed sources appropriate for the NBHMA were mature and ready to be planted, ODA staff, in cooperation with BLM and USFWS, decided to utilize these plants to augment two existing sites within the NBHMA. Creating new populations in the sites identified within the NBMHA in 2010 continues to be a priority for recovery of *P. hirtus*, and plantings are planned for the near future.

The Soggy Bottoms (NWYC) site is bisected by a small stream that was impacted by disturbance associated with controlled burning in 2003, and the population here has not been as successful as the one established at the Westgate site. The NWYC portion of the site is located east of this stream, and consists of a series of ponds that have been planted several times with *P. hirtus.* (See Maddux et al. 2007 and Amsberry and Meinke 2010 for details of these plantings.) In the current study, plants were planted at one location in the Soggy Bottoms area and one further east at the edge of the NWYC portion of the site (Figure 8).

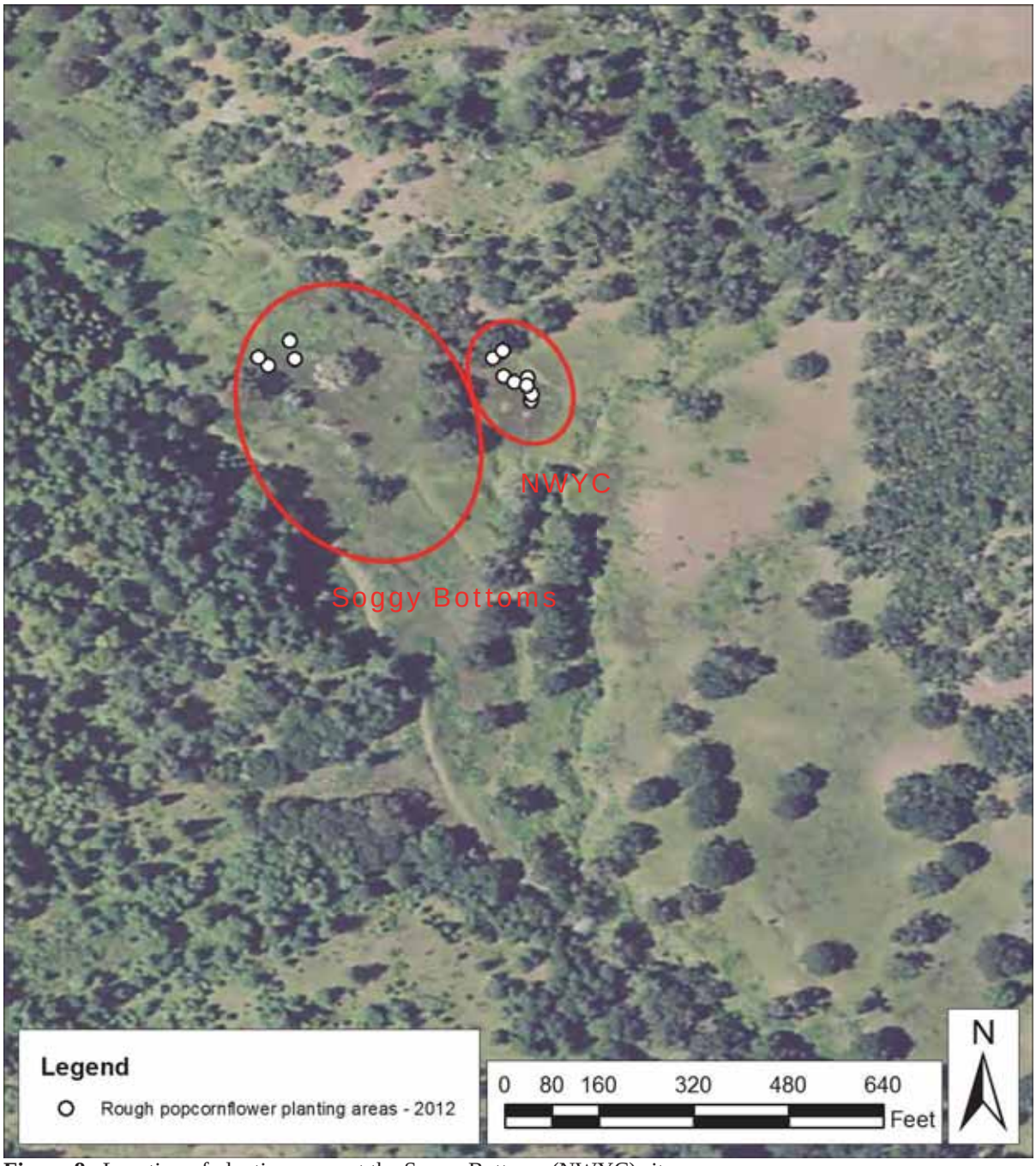

Figure 8. Location of planting areas at the Soggy Bottoms (NWYC) site.

Westgate - NBHMA

This site supports the most successful created population to date (Figures 9 and 10). Population dynamics mimic those of a naturally occurring population, with numbers of plants fluctuating in response to environmental conditions. Plants consistently produce large amounts of seed, and seedlings germinate and grow throughout most of the suitable wetland

habitat. Removal of competing vegetation by BLM helps maintain this population (Golub-Tse et al. 2012), and its large, self-sustaining nature makes it a significant contributor to the viability of this species. See Amsberry and Meinke 2010, Brown et al. 2011 and Golub-Tse et al. 2012 for more information on the population in this site.

Figure 9. The approximate perimeter of the large population created in 1998/1999 at the Westgate site is outlined in red, with the location of the augmentation plantings shown as white dots.

Figure 10. The population at the Westgate site has thrived since its creation in 1998/1999, with 3,300-23,000 plants present each year. High quality habitat, management of competing vegetation by BLM, and use of genetically diverse founders contribute to the success of this population creation project.

Methods

Transplant production

Using previously developed protocols (Amsberry and Meinke 1999), cultivation of 1,600 transplants begun in January 2012, with planting scheduled for March. Seeds collected from seven sites as part of Year 1 of this project (Wilson et al. 2010) were placed on moist filter paper in petri dishes and transplanted into 4" nursery pots filled with Metro Mix® MM840PC soil as they

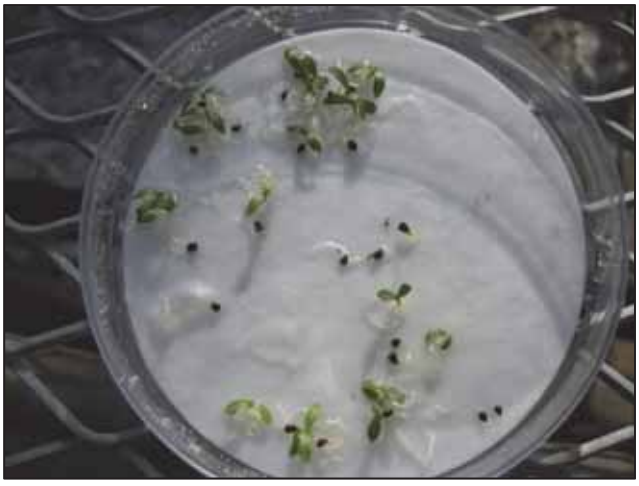

Figure 11. Seeds were placed in petri dishes, then transplanted to pots as they germinated.

Figure 12. Seedlings were cultivated in the greenhouses at Oregon State University until mature, then transported to transplant sites in trucks fitted with customized racks.

germinated. Plants were fertilized weekly with Dyna Gro® 7-9-5 fertilizer and watered every day. Once plants were sufficiently developed to be suitable for transplanting, they were transferred to the selected sites in the last week in March (Figure 12). In summer of 2012, an additional 1,584 plants were cultivated and prepared for the fall planting efforts. Only plants grown from seed collected from populations located in the same Recovery Unit (USFWS 2003) as the transplanting site were planted at each location.

Outplanting

In March 2012, 448 plants were planted at the Del Rio North site, 560 at Del Rio South (section A) and 536 at Soggy Bottoms (NWYC) for a total of 1,544 plants. Nine planting locations were selected in the two Del Rio sites by USFWS/ODA staff (Figure 3), and two microsites at Soggy Bottoms (NWYC) were selected by ODA staff in cooperation with BLM botanists (Figure 8). Plants were not planted in arrays, but were clustered in the most suitable habitat within these designated sites. Planted areas were flagged, and GPS points and

number of plants planted at each location were recorded. (GPS data are available from ODA.)

Figure 13. Flats of transplants were placed on brush piles in an attempt to prevent them from being swept away by the flood waters of Sutherlin Creek.

Our initial attempt at planting at the Del Rio sites on March 21 was discontinued due to high water (Figure 13). As water from the adjacent Sutherlin Creek flooded into the selected planting locations, we moved plants to higher ground within the site. Water continued to rise, and we were eventually forced to vacate the area. The remaining the plants were planted the following week. Unfortunately, upon our return planting visit, a few flats of plants could not be re-located (presumably because they washed away in the flood), resulting in slightly fewer plants than anticipated being planted in these sites. Due to the high water levels, watering plants as they were planted was not needed. Plants planted in this site were grown from seeds collected from populations in the Sutherlin Creek Recovery Unit: TNC's Popcorn Swale Preserve, the privately owned North Star population located along Sutherlin

Creek near Sutherlin, the City of Sutherlin's population in Central Park, and the Douglas County Soil and Water Conservation District's site on Sutherlin Creek.

At Soggy Bottoms, plants were transferred from the staging area to the planting sites using UTVs (Figure 14). The areas selected for planting were mowed by BLM in fall 2011 to reduce competition by existing vegetation. PVC stakes were placed around the planting areas to help locate plants during monitoring, and GPS points were recorded. Seed sources included the Soggy Bottoms site itself, as well as the Westgate and the Sutherlin Creek sites. The soil was very wet, and watering was not needed.

Figure 14. Due to the nature and location of the planting sites, transplants were transported by UTV, and planted into standing water.

In October 2012, an additional 928 plants were planted in the Del Rio South site (section B), 512 plants were planted at Orenco Ponds, and (as recommended in Wilson et al. 2010), 144 plants were planted to augment the genetic diversity of the established population at the Westgate site. The ground was dry at this time and additional water was applied as plants

were planted (front cover photo). GPS locations were recorded along with information on the number of plants planted. All plants planted at the Del Rio and Orenco Ponds sites were grown from seed collected at the North Star and Popcorn Swale sites, and those planted at Westgate were grown from all available seed.

Census of transplants and reproductive data collection

In order to quantify initial mortality and fecundity of transplants, monitoring was completed in mid-June 2012 at all sites planted in March 2012 (the Del Rio North site, section A of the Del Rio South site, and Soggy Bottoms). This baseline monitoring consisted of counting all plants, and estimating the mean reproductive capacity of a selected subsample in each site.

Reproductive capacity = mean number of inflorescences/plant x mean number of flowers/inflorescence x mean number of seeds/flower.

Figure 15. Initial monitoring of the Del Rio South site (above) and the Orenco Ponds site (below) was completed in July 2013.

Plants planted in October 2012 (at the B section of Del Rio South, Orenco Ponds and Westgate) were monitored in July 2013 using a similar (but not identical) methodology. This baseline monitoring information is valuable for documenting losses due to transplant shock and quantifying broad trends in survival and fecundity. Due to differences in the amount of

time plants had been in the ground at the two monitoring dates (eight months for the October planting, and three months for the March planting), and differences in monitoring methodology, this dataset is not appropriate for making specific comparisons among sites. Comparisons will be made using the data from the monitoring of all plants in all sites that is scheduled for July 2014.

Results

Plants planted at the Del Rio North and the A section of Del Rio South (in March 2012) survived well, with 91.0% of plants evident in June 2012 (Figure 16). The plants here were also very large (as measured by the number of inflorescences per plant; Figure 17), and produced many flowers (Figure 18). Plants produced approximately the same mean number of seeds/flower as did plants in the year after planting in previous outplanting efforts (Figure 19; Amsberry and Meinke 2002). The large size and high number of flowers produced per plant resulted in a very high reproductive capacity for plants in these sites (Figure 20).

Although plants at Del Rio South Section B (planted in October 2012 and monitored in July 2013) appeared large and healthy (Figure 15), monitoring data indicate that they survived at lower rates, were smaller, and had fewer flowers than their counterparts that were planted in the previous spring. These differences may be due to the differences in monitoring date and methodology; monitoring of all plants at the same time and using the same methodology will help determine the biological validity of these initial differences.

Results from the initial monitoring at Orenco Ponds are disappointing. A lower percentage of plants survived here than in any other site, plants were smaller than those in other sites, produced fewer flowers, and matured an abnormally low number of seeds per flower. Survival varied greatly among the five pools planted at this site, with 93.8% surviving in Pool 1, 41.1% in Pool 2, 30.2% in Pool 3, 26.3% in Pool 4, and 68.8% in Pool 5 (Figure 6), indicating that future transplanting should focus on Pools 1 and 5.

Plants at Soggy Bottoms and Westgate performed as expected, with those in the Westgate site surviving especially well. Again, temporally standardized monitoring is needed to evaluate the ultimate success of our planting efforts.

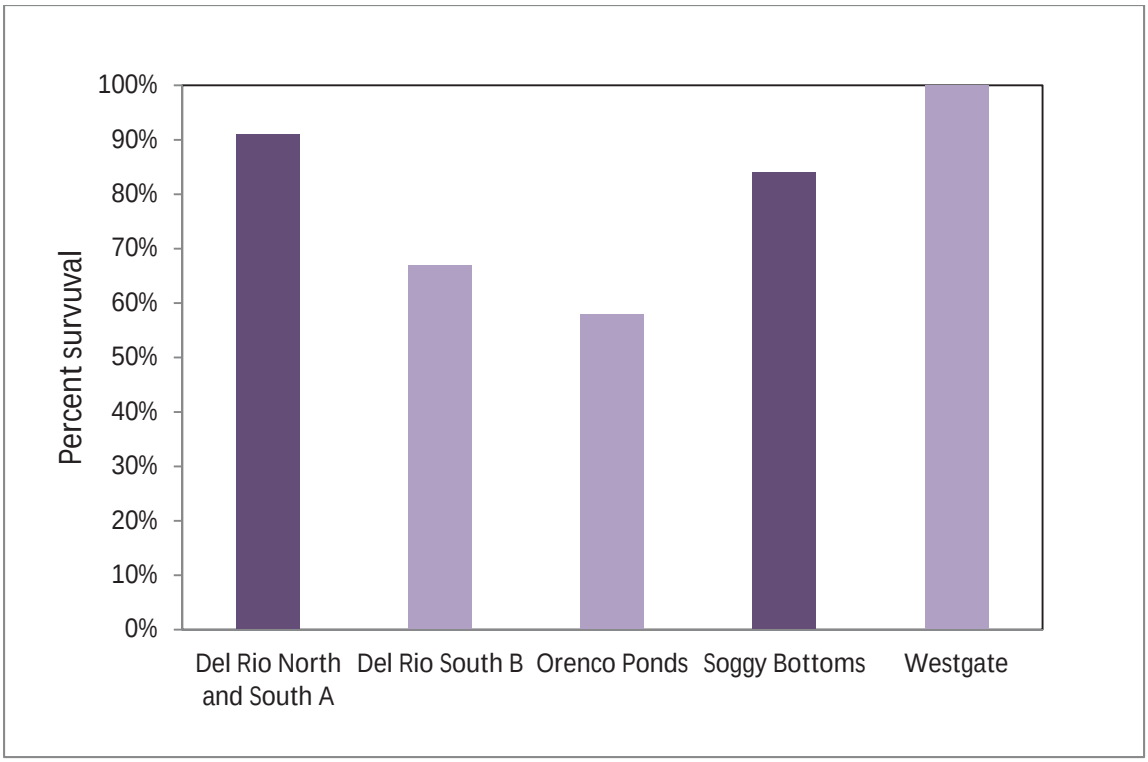

Figure 16. Plants in the Westgate site survived best, while those at Orenco Ponds survived at the lowest rates. Spring-planted sites are represented with dark bars, those planted in the fall with light colored bars.

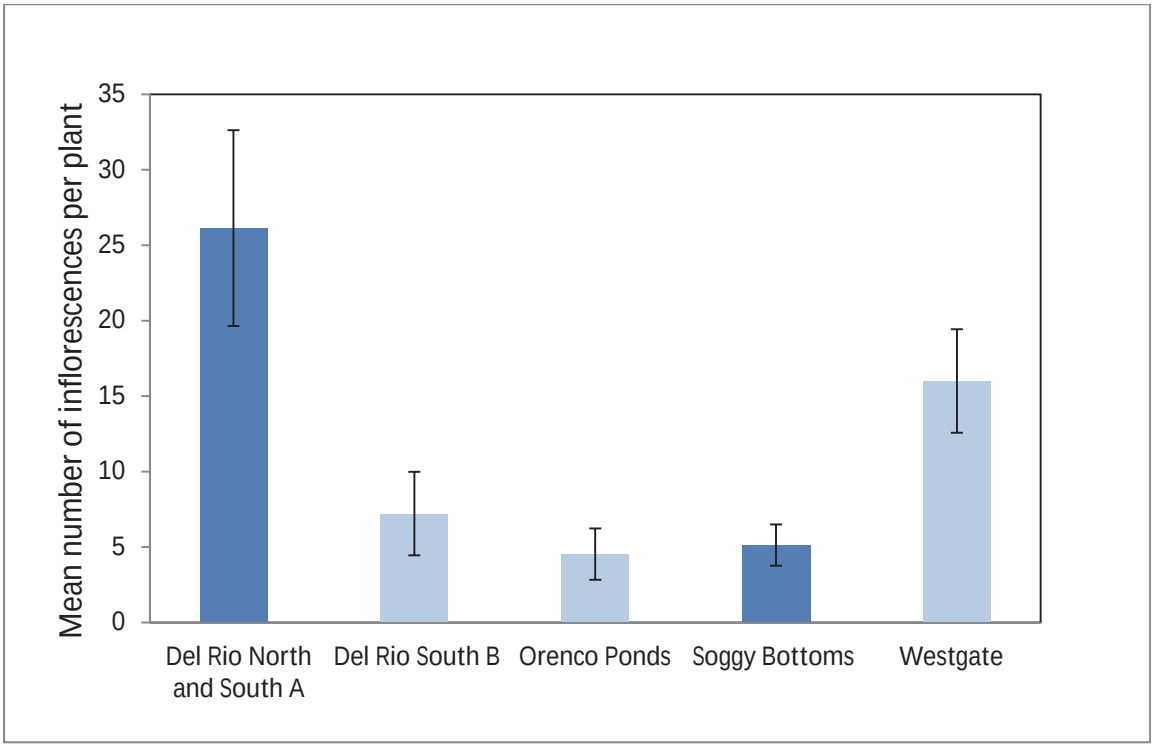

Figure 17. Plants in the Del Rio North and South (section A) were larger than those in all other sites. Spring-planted sites are represented with dark bars, those planted in the fall with light colored bars. n= 15 for Del Rio North and South A, n=18 for Del Rio South B, n=15 for Orenco Ponds, n= 30 for Soggy Bottoms and n=4 for Westgate. Error bars represent 95% confidence intervals.

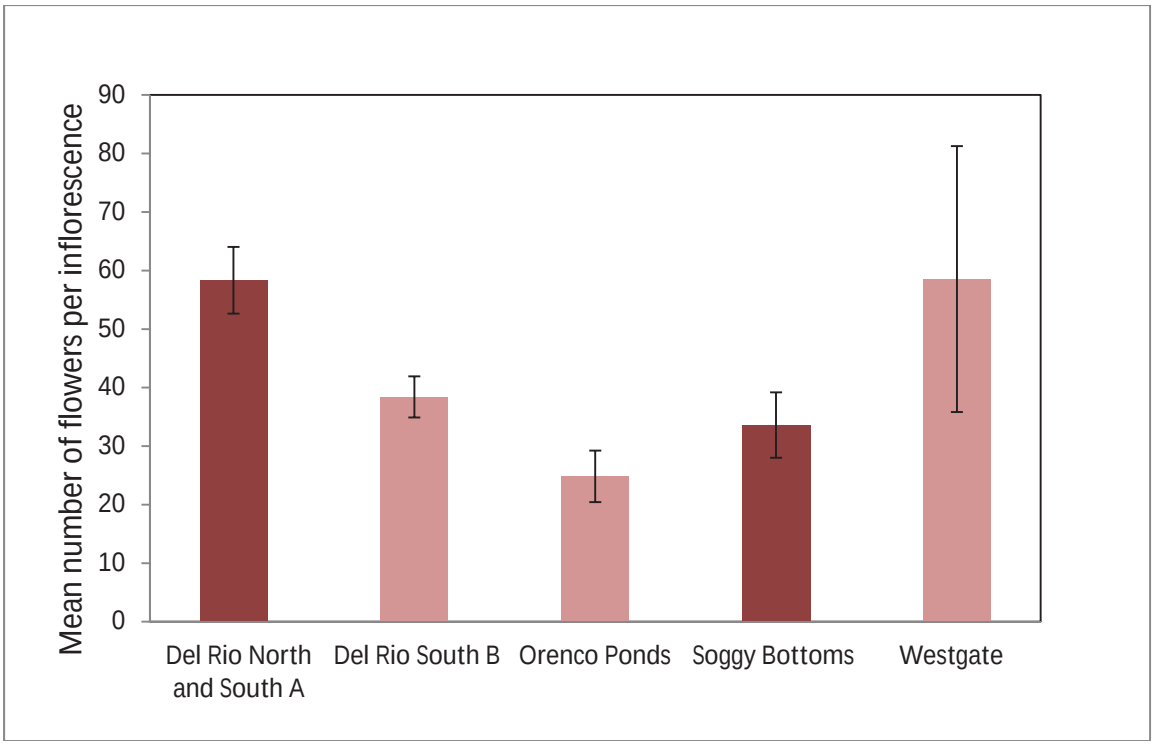

Figure 18. The mean number of flowers/inflorescence varied among sites. Spring-planted sites are represented with dark bars, those planted in the fall with light colored bars. n= 66 for Del Rio North and South A, n=83 for Del Rio South B, n=36 for Orenco Ponds, n= 105 for Soggy Bottoms and n=13 for Westgate. Error bars represent 95% confidence intervals.

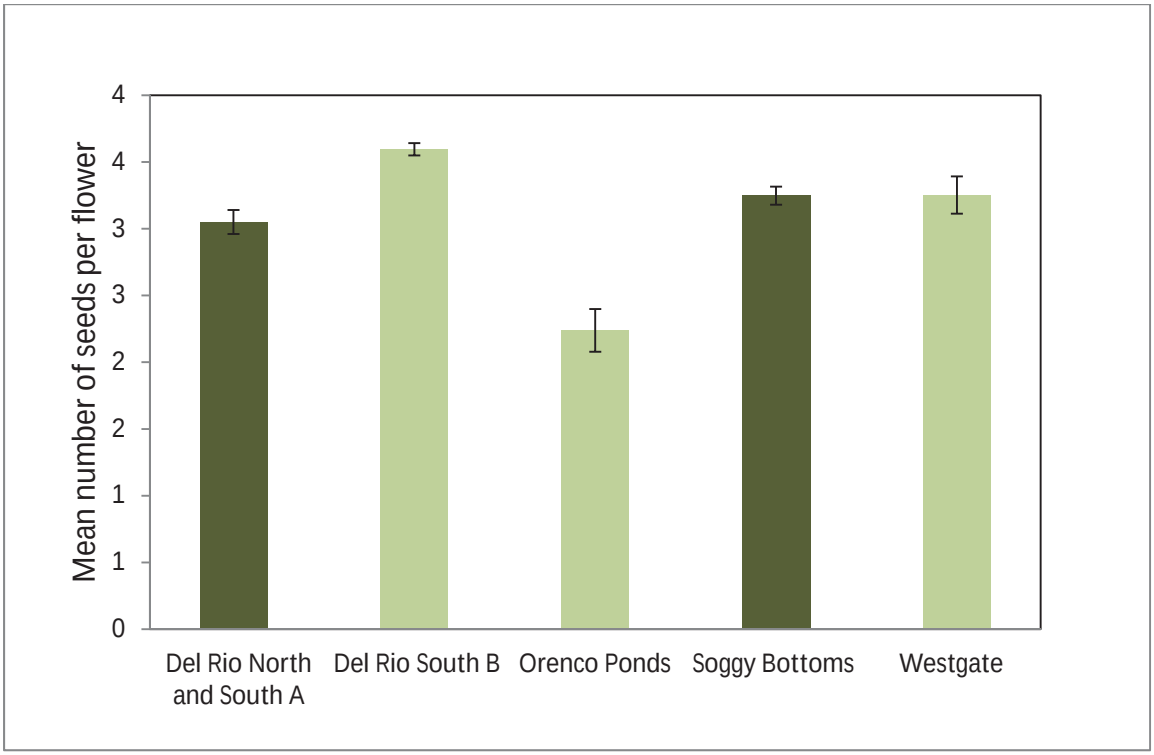

Figure 19. The mean number of seeds/flower produced was fairly consistent among sites, with the exception of the Orenco Ponds site. Spring-planted sites are represented with dark bars, those planted in the fall with light colored bars. n= 804 for Del Rio North and South A, n=1145 for Del Rio South B, n=290 for Orenco Ponds, n= 1351for Soggy Bottoms and n= 265 for Westgate. Error bars represent 95% confidence intervals.

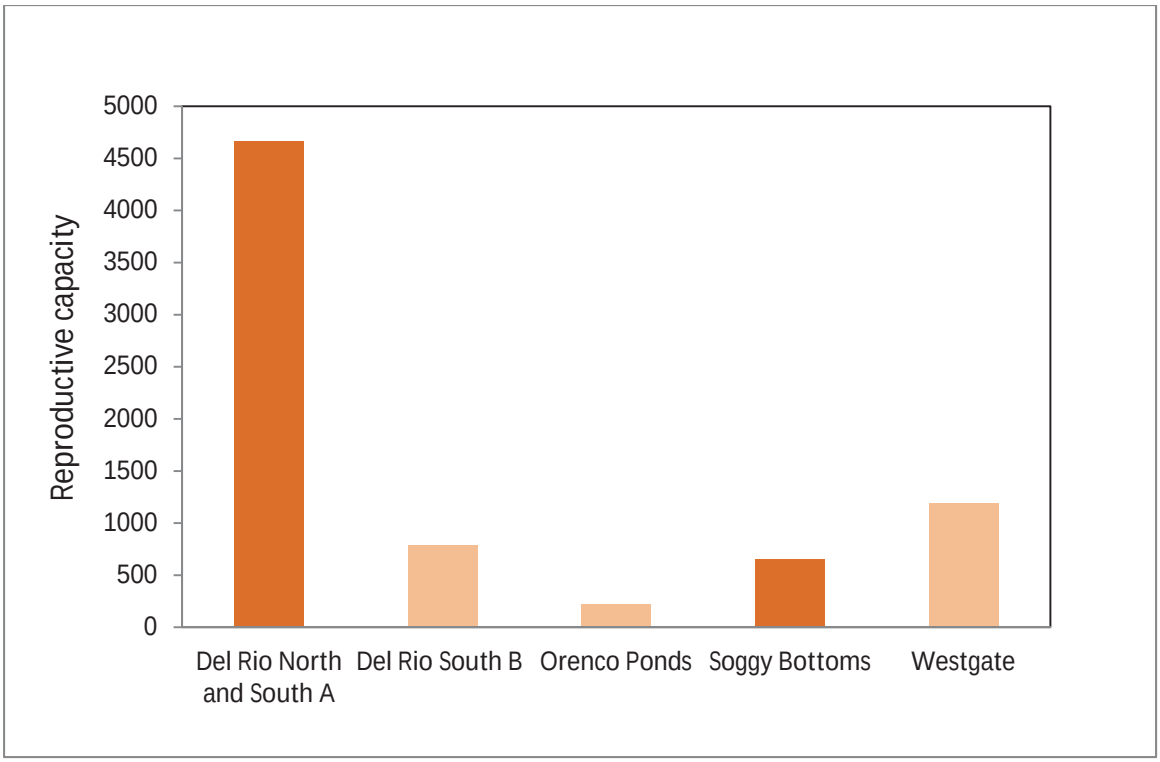

Figure 20. The large size (as measured by the number of inflorescences) of plants in the Del Rio North and South A sites resulted in a very mean high reproductive capacity for this site. Spring-planted sites are represented with dark bars, those planted in the fall with light colored bars. **Reproductive capacity** = mean number of inflorescences/plant x mean number of flowers/inflorescence x mean number of seeds/flower

Discussion

The results from our initial monitoring are promising. The Del Rio North and South sites appear to provide suitable habitat for *P. hirtus*, and additional areas suitable for transplanting are available (Figure 3). The high potential for successfully creating new populations in these sites is not surprising, as the vegetation is largely native, the hydrology appears suitable, and a few plants already occurred here prior to the commencement of the current outplanting efforts. Non-native trees have been removed from the wetland areas, and a treatment plan for controlling herbaceous weeds is in place. These two sites have the potential to support large, self-sustaining populations of *P. hirtus* and contribute to recovery.

Plants in the Orenco Ponds site survived poorly, were quite small and produced few seeds. The restored habitat at this site is fairly low quality, with soils and hydrology that were altered during the site's previous incarnation as a log pond, and large infestations of exotic weeds. Initial efforts to increase the native component of the vegetation (Figure 21) were not

successful, although future monitoring may document emergence of plants from seeds sown at this time. Plants here also experienced high levels of browsing, probably by deer or geese. Herbivory reduced biomass of transplants (Figure 22), and some plants were apparently removed from the ground completely by the browsing animals. Next year's monitoring will provide data crucial to evaluating the potential of this site to contribute to recovery.

Figure 21. Bob Meinke (ODA; right) and Sam Friedman (USFWS; left) sowed seeds of *Beckmannia syzigachne* at Orenco Ponds in 2012 with the goal of increasing the native composition of this created wetland.

At the Soggy Bottoms (NWYC) site, plants were planted in two areas. Unfortunately, monitoring data were not collected separately in these two areas in 2012, so independent evaluation of the two sites is not possible at this time. Next year's monitoring will be conducted with the goal of evaluating the two microsites.

Figure 22. Browsed plant at Orenco Ponds.

Augmentation at the Westgate site was successful, with additional genetic diversity added to the already established population. This created population is the largest and most prolific one known. Although it is located outside of currently designated Recovery Units, its size and self-sustaining nature make it a significant contributor to the viability and recovery of *P. hirtus.*

An additional outplanting project was completed by ODA as a prologue to the completion of Year 1 of this study. Over four hundred seedlings were produced as part of the germination and maternal line testing completed in Year 1 (Wilson et al. 2010). However, no funding had been allocated for cultivating or planting these plants. Because ODA staff did not want these rare plants to "go to waste", we continued the cultivation of these seedlings in the greenhouse. And on a freezing December day in 2010, three OSU students, along with Julie Worsley (ODOT) and Sam Friedman (USFWS), volunteered to help plant them at an ODOT mitigation site east of I-5 near Wilbur (Figure 23).

Figure 23. Four hundred and eighty-six transplants produced as a by-product of germination and maternal line testing were planted in December 2010 to augment the existing population at the Wilbur site.

Recommendations

- In June 2014, monitor all populations created during this project. Standardized data (collected at the same time, and using the same methodology) for all sites is necessary to determine the success of our planting efforts.

- Continue to coordinate with BLM to initiate plantings at the NBHMA sites identified in Year 1 of this project.

- Evaluate data from the populations created by this project with the goal of quantifying our progress toward recovery and downlisting.

- Using data from this project, develop plans for completing the final work needed to meet downlisting criteria.

- Compile information on all successful population creation projects to date, and prepare a manuscript describing these efforts for publication.

Acknowledgments

We would like thank Jake Kercher and Julie Worsley (ODOT) for providing access to the Del Rio sites, advising on the selection of planting locations, and assisting with the March 2012 planting. Jake also braved the rising floodwaters of Sutherlin Creek to save transplants from being washed away, and assisted with the October planting and the July 2013 monitoring, and Julie helped with the December 2010 planting at the Wilbur site – thank you Jake and Julie! Susan Carter (Roseburg BLM) and Julie Knurowski (Roseburg BLM- now retired) provided access and assistance for the Soggy Bottoms and Westgate plantings, and Susan generously assisted with the October Del Rio planting as well. Julie skillfully transported plants to the Soggy Bottoms site, and, as always, provided invaluable advice on a variety of topics. We will miss you, Julie! Tom Manton (Douglas County Public Works) provided access to the Orenco Ponds site, and a group of NRCS volunteers helped with transplanting in this site - we thank them also. Sam Friedman's contributions were essential to the completion of this study: Sam provided planting location advice for the Orenco Ponds and Del Rio sites, assisted with planting and monitoring in both sites (as well as the extra planting at Wilbur), and collected and sowed native grass seed to improve habitat at Orenco Ponds – thank you Sam! OSU students Alexis Brickner and Matt Groberg, along with ODA seasonal staff member Amy Golub-Tse completed the 2012 monitoring and we thank them also. Thanks to Bridget Chipman (ODA) for her help with monitoring in 2013, and for completing the bulk of the data entry and analysis. Ashley Johnson (OSU/ODA) toiled for many months in the OSU greenhouses to cultivate over 3,000 transplants, and we thank her also. And thanks to OSU students Benjahmin Boschee, Julia McGonigle and Matt Gorberg for helping our excess popcorn flowers find their way home. Finally, special thanks to Jordan Brown (ODA) for his expert planting and monitoring, his conscientious attention to the details of documentation in both the field and office, and his truly amazing ability to make everything run smoothly! Photos by ODA staff; maps by Jordan Brown. Funding provided by USFWS, OR-EP-2, segment 24.

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Literature cited

Amsberry, K. 2001. Conservation biology of *Plagiobothrys hirtus* (Boraginaceae): evaluation of life history strategy and population enhancement. M.S. thesis, Oregon State University, Corvallis, Oregon.

Amsberry, K. and R.J. Meinke. 1997. Status report for *Plagiobothrys hirtus*. Status report prepared for the U.S. Fish and Wildlife Service, Portland, Oregon. Oregon Department of Agriculture, Salem, Oregon.

Amsberry, K. and R.J. Meinke. 1998. *Plagiobothrys hirtus* reintroduction project. Progress report prepared for the U.S. Fish and Wildlife Service, Portland, Oregon. Oregon Department of Agriculture, Salem, Oregon.

Amsberry, K. and R.J. Meinke. 1999. *Plagiobothrys hirtus* reintroduction project - final report for 1998-1999. Progress report prepared for the Bureau of Land Management, Roseburg District Office. Oregon Department of Agriculture, Salem, Oregon.

Amsberry, K. and R.J. Meinke. 2002. *Plagiobothrys hirtus* reintroduction project - final report for 2001. Progress report prepared for the Bureau of Land Management, Roseburg District Office. Oregon Department of Agriculture, Salem, Oregon.

Amsberry, K. and R.J. Meinke. 2010. *Plagiobothrys hirtus* reintroduction project and population monitoring 2009 final report. Report prepared for Bureau of Land Management, Roseburg District Office. Oregon Department of Agriculture, Salem, Oregon.

Brown, J.A., K. Amsberry and R.J. Meinke. 2011. Annual program performance report for rough popcorn flower (Plagiobothrys hirtus): reintroduction and monitoring in 2010.

Franklin, J.F. and C.T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. USDA Forest Service General Technical Report PNW-8. Pacific Northwest Forest and Range Experiment Station, Portland.

Golub-Tse, Amy, K. Amsberry and R.J. Meinke. 2012 Annual program performance report for rough popcorn flower (*Plagiobothrys hirtus*) Reintroduction and monitoring in 2012. Report prepared for Bureau of Land Management, Roseburg District Office. Oregon Department of Agriculture, Salem, Oregon

Maddux, T., K. Amsberry, and R.J. Meinke. 2007. *Plagiobothrys hirtus* reintroduction project: 2006 final report. Progress report prepared for the Bureau of Land Management, Roseburg District Office. Oregon Department of Agriculture, Salem, Oregon.

Natural Resources Conservation Service. 1997. Soil Survey Geographic (SSURGO) database for Douglas County, Oregon. USDA Natural Resources Conservation Service, Fort Worth, Texas. http://www.ftw.nrcs.usda.gov/ssur.html, accessed August 2000.

Oregon Department of Agriculture (ODA). 2013. Noxious Weeds Quarantine, List B. Oregon Department of Agriculture, Salem, Oregon, http://www.oregon.gov/ODA/PLANT/pages/603_052_1200.aspx, accessed January 6, 2014.

Oregon Natural Heritage Information Center. 2008. Oregon Natural Heritage Information Center, Portland, Oregon.

Ridenour, W.M. and R.M. Callaway. 2001. The relative importance of allelopathy in interference: the effects of an invasive weed on a native bunchgrass. Oecologia **126**: 444-450.

Soil Survey Division. 2000. Official soil series descriptions. USDA Natural Resources Conservation Service, Washington D.C. http://www.statlab.iastate.edu/soils/osd, accessed August 2000.

U.S. Fish and Wildlife Service. 2003. Recovery plan for the rough popcornflower (*Plagiobothrys hirtus*). USFWS, Portland, Oregon.

Visher S. 1954. Climatic Atlas of the United States. Harvard University Press, Cambridge.

Wilson, C., K. Amsberry and R.J. Meinke. 2010. Recovering *Plagiobothrys hirtus* through creation of new populations in protected sites 2010 Report. Report prepared for the U.S. Fish and Wildlife Service, Portland, Oregon. Native Plant Conservation Program, Oregon Department of Agriculture, Salem, Oregon.