U.S. Fish & Wildlife Service

Recovery Plan for the Rough Popcornflower

(Plagiobothrys hirtus)

RECOVERY PLAN

FOR THE

ROUGH POPCORNFLOWER

(*Plagiobothrys hirtus*)

Region 1

U.S. Fish and Wildlife Service

Portland, Oregon

Approved: _____

Regional Director, Region 1, U.S. Fish and Wildlife Service

Date: JUL 28 2003

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Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service (Fish and Wildlife Service), often with the assistance of recovery teams, contractors, State agencies, and others. Objectives will only be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints. Recovery plans do not necessarily represent the views nor the official positions or approvals of any individuals or agencies, other than the Fish and Wildlife Service, involved in the plan formulation. They represent the official position of the Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

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An electronic version of this recovery plan is also available at http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm and http://endangered.fws.gov/recovery/index.html.

ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

Current Status: The rough popcornflower (*Plagiobothrys hirtus* (Greene) I.M. Johnston) is a federally listed endangered plant species (U.S. Fish and Wildlife Service 2000) with 17 known extant occurrences distributed only in the Umpqua River drainage in Douglas County, Oregon. This species occurs along the Sutherlin Creek drainage from Sutherlin to Wilbur, adjacent to Calapooya Creek west of Sutherlin, and in roadside ditches near Yoncalla Creek just north of Rice Hill. The rough popcornflower has an annual or short-lived perennial life history.

Habitat Requirements and Limiting Factors: The rough popcornflower occurs only in swales or seasonal wet meadows where it remains submerged under standing water from late fall through spring. The majority of the extant and extirpated sites occur on the Conser soil silty clay loam series (deep, poorly drained soils present in depressions in alluvial stream terraces).

Most of the sites are moderately to highly disturbed due to agricultural and development activities. Urban and agricultural development, invasion of nonnative species, habitat fragmentation and degradation, and other human-caused disturbances have resulted in substantial losses of seasonal wet meadow habitat throughout the species' historic range. Conservation needs include establishing a network of protected populations in natural habitat distributed throughout its native range.

Recovery Priority Number: The recovery priority number for the rough popcornflower is 2 on a scale of 1 to 18, indicating that it is: 1) taxonomically, a species; 2) facing a high degree of threat; and 3) rated high in terms of recovery potential.

Recovery Objective: Downlist to threatened. Interim goals of this recovery plan include stabilizing and protecting populations, conducting research necessary to refine reclassification and recovery criteria.

Recovery Criteria: The rough popcornflower should be considered for downlisting when all of the following criteria are met:

1. At least 9 reserves, containing a minimum of 5,000 plants each, are protected and managed to assure their long-term survival.

2. A minimum of 1,000 square meters (10,764 square feet) are occupied by the rough popcornflower within each reserve, with at least 50 square meters (538 square feet) having a density of 100 plants/square meter (100 plants/11 square feet) or greater.

3. A minimum of nine reserves are distributed among the three natural recovery units (Calapooya Creek, Sutherlin Creek, and Yoncalla Creek), with at least three reserves present in each recovery unit.

4. Patches contained in each reserve are within 1 kilometer (0.6 mile) (Levin 1993) of at least one other to allow pollinator movement and gene flow among them.

5. Five years of demographic data indicate that populations in at least seven of the nine reserves within the three recovery units have average population numbers that are stable or increasing, without decreasing trends lasting more than 2 years.

6. Seventy-five percent or more of the plants are reproductive each year, with 30 percent annual seed maturation and recruitment evident in all populations.

The rough popcornflower is not considered delistable at this time unless viable natural occurrences meeting the six recovery criteria, in the native habitat can be secured and protected. Specific criteria for delisting cannot be developed until natural occurrences meeting these conditions are located and protected.

Actions Needed:

1. Conserve and manage existing patches and develop new protected populations within each recovery unit.

2. Establish long-term, *ex situ* conservation of rough popcornflower seeds.

3. Research factors that threaten recovery of the species.

4. Provide outreach and education opportunities for land managers/landowners.

Total Cost of Downlisting ($1,000):

Year	Need 1	Need 2	Need 3	Need 4	Total
2004	130	15	40	05	190
2005	238	05	40	05	288
2006	338		40	05	383
2007	280			05	285
2008	280			05	285
2009	280			05	285
2010	280			05	285
2011	280			05	285
2012	280			05	285
2013	280			05	285
Total	2,666	20	120	50	2,856

Date of Downlisting: Downlisting may be considered in 2013 if the recovery criteria have been met.

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I. INTRODUCTION

The rough popcornflower (*Plagiobothrys hirtus* (Greene) I.M. Johnstson) was collected occasionally in the Umpqua Valley of Douglas County, Oregon, from 1887 to 1961. However, by 1978, no extant populations were known (Siddall and Chambers 1978). Surveys in the early 1980's rediscovered several populations, all within the Umpqua Valley drainage. All extant populations are small, and all have been impacted since the time of European settlement by the conversion of wet meadow habitat to agricultural use, and more recently by rapid urban and industrial development in the Sutherlin area. In response to this anthropogenic decline, we, the U.S. Fish and Wildlife Service (Service), listed the rough popcornflower (also called the hairy popcornflower) as endangered on January 25, 2000 (U.S. Fish and Wildlife Service 2000). This species is also listed as endangered by the State of Oregon (OAR 603-73-070).

Description

The rough popcornflower is an herbaceous plant which can be 50 to 70 centimeters (20 to 28 inches) tall and perennial or less often, considerably smaller and annual, depending on environmental conditions (Amsberry and Meinke 1999). The upper stems are distinctly hairy with hairs perpendicular to the stem, and the bright green, simple linear leaves have hairy margins. Flowering stems are spreading, with paired coiled inflorescences bearing white, five-petaled flowers with yellow centers (fornices). Large plants can consist of over 50 flowering stems, and each stem produces 10 to 100 flowers. As in most members of the Boraginaceae family, anthers are included and epipetalous (having stamens attached to the inner corolla surface). Each flower can produce four tan-colored to black nutlets; due to fruit abortion or lack of pollination, calyces (the outer sets of floral leaves of the flower) with fewer than four nutlets are often observed.

The rough popcornflower and fragrant popcornflower (*Plagiobothrys figuratus*), another species of popcornflower found throughout western Oregon, are both members of the subgenus *Allocarya*, (Abrams 1951, Peck 1961) and are quite similar in appearance. The rough popcornflower is the larger of the two, growing to 70 centimeters (28 inches) in height (fragrant popcornflower generally

reaches only 15 to 45 centimeters [6 to 18 inches]), with stouter stems (4 to 5 millimeters [3/8 inch] wide as compared to approximately 2 millimeters [3/16 inch] in fragrant popcornflower), and often larger flowers. Nutlets, the basis for taxonomic differentiation within *Plagiobothrys*, are remarkably similar in the two species, although the attachment scar is generally basal in rough popcornflower, and lateral in fragrant popcornflower. In the field, the two taxa are readily discernable by the distinctly spreading (rather than appressed) pubescence, large size, and facultatively perennial nature of rough popcornflower, which easily distinguish it from fragrant popcornflower, as well as Scouler's and rusty popcornflower (*Plagiobothrys scouleri* and *P. nothofulvus*) that are present in the range of the rough popcornflower. Seedlings of the rough popcornflower germinate in fall and overwinter as submerged rosettes; this aquatic juvenile stage is similar in appearance to the rosettes of many species of wetland plants, and is difficult to identify.

Distribution

The rough popcornflower is found only in the Umpqua River drainage in Douglas County, in southwest Oregon, at sites ranging from 100 to 230 meters (328 to 755 feet) in elevation (R. Meinke, pers. comm. 2003). Extant, naturally occurring populations of this species occur along the Sutherlin Creek drainage from Sutherlin to Wilbur, adjacent to Calapooya Creek west of Sutherlin, and in roadside ditches near Yoncalla Creek just north of Rice Hill. The northernmost reported site is near Yoncalla, Oregon, and the southernmost at Wilbur, Oregon. Until 1998, all known sites were east of Interstate Highway 5 (I-5), but a site has been discovered at the junction of Stearn's Lane and Highway 138, 0.8 kilometer (0.5 mile) west of I-5. The easternmost currently known extant population is just east of Plat K Road outside Sutherlin, Oregon. Historical collections were made farther east near Nonpareil, but more recent surveys (1998 to 1999), although limited due to private ownership of most land in that area, did not locate any populations of this species. Collections from outside the current range of extant populations of rough popcornflower in Douglas County are probably misidentified collections of fragrant popcornflower (K. Amsberry, pers. comm. 2003b).

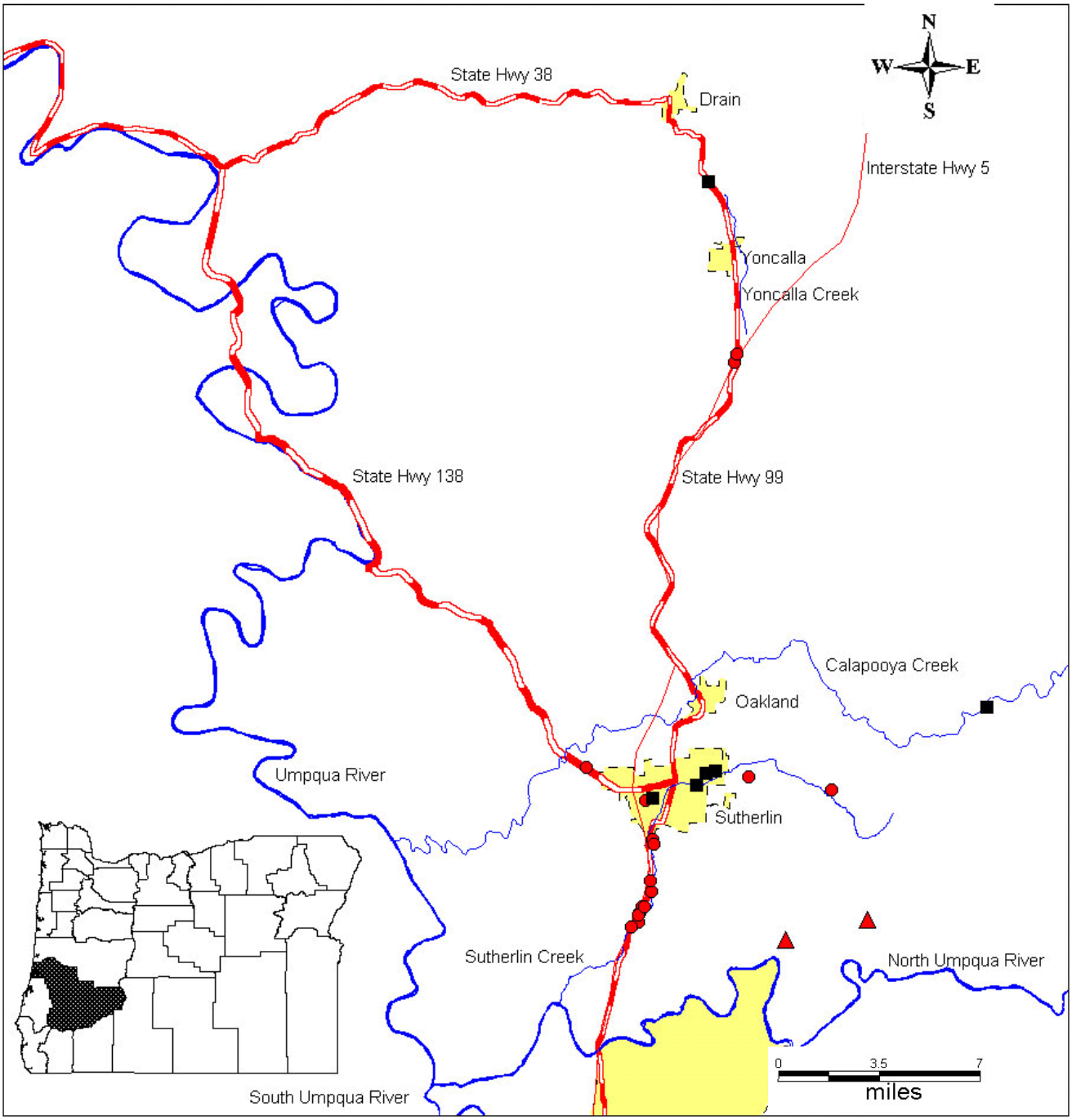
In the final listing rule for the rough popcornflower, we described 17 extant populations or patches of the rough popcornflower based on information from our files, Oregon Department of Agriculture, The Nature Conservancy, and the Oregon Natural Heritage Program (U.S. Fish and Wildlife Service 2000). A recent review of the Oregon Natural Heritage Program database indicates that, since the initial collection and description of the rough popcornflower, this species has been reported and/or collected from a total of 15 naturally occurring sites (not including populations created as part of mitigation or enhancement projects). Apart from an additional site that was identified by us and not in the Oregon Natural Heritage Program database, these sites are represented by the Oregon Natural Heritage Program as element occurrences. Several Oregon Natural Heritage Program sites include multiple patches (all known sites are listed in Appendix 1) (Map 1).

Throughout this plan, "occurrence," "site," "patch," or "population" as described in the listing rule (U.S. Fish and Wildlife Service 2000) will represent a site. These terms are used in a practical sense to indicate the occurrence of one or more plants at a defined geographical location, and not to imply that the designated group of plants is necessarily a "population" in the strict biological sense of the word. As an aid to the reader, site names provided in Appendix 1 are followed by the Oregon Natural Heritage Program Element Occurrence (EO) number(s) in parentheses.

In addition to the naturally occurring populations, rough popcornflower transplants have been introduced at two sites on the North Bank Habitat Management Area, a Bureau of Land Management Area of Critical Environmental Concern on North Bank Road east of Wilbur. These sites occur along two small drainages: Soggy Bottom and Chasm Creek, which drain directly into the North Umpqua River. A population was also introduced on private land as part of a mitigation project by Land and Water Environmental Services, Inc. (J. Barnes, pers. comm. 2000). This site is on Sutherlin Creek, just west of I-5, across the highway from The Nature Conservancy's William Oerding Popcorn Swale Preserve.

Map 1. Rough popcornflower known occurrences in Douglas County, Oregon.

- Extant Population
- Extirpated Population
- Introduced population*



* Bureau of Land Management: North Bank Habitat Management Area

Five patches are considered protected. Two patches (EO*004) are owned by the Oregon Department of Transportation and three patches, which constitute the Popcorn Swale Preserve (EO*009), are managed by The Nature Conservancy for the rough popcornflower. The remaining extant populations are on private, commercial, residential, and agricultural land. Protection can be achieved through a variety of means: permanent protection of sites on public lands through management plans, acquisition through purchase or land exchange, and long-term or permanent conservation agreements or easements with willing landowners.

To ensure that the rough popcornflower is conserved throughout its range, and that the genetic diversity currently present in this species is maintained, we have assigned each known natural population to one of three recovery units (Map 2). The recovery units correspond to drainage basins within the North Umpqua system, and represent groups of populations which are the most genetically similar. The populations of rough popcornflower in each recovery unit are also morphologically distinct from those in other populations, as some are generally larger than other plants, and have a greater tendency to exhibit a perennial life history (Amsberry 2001).

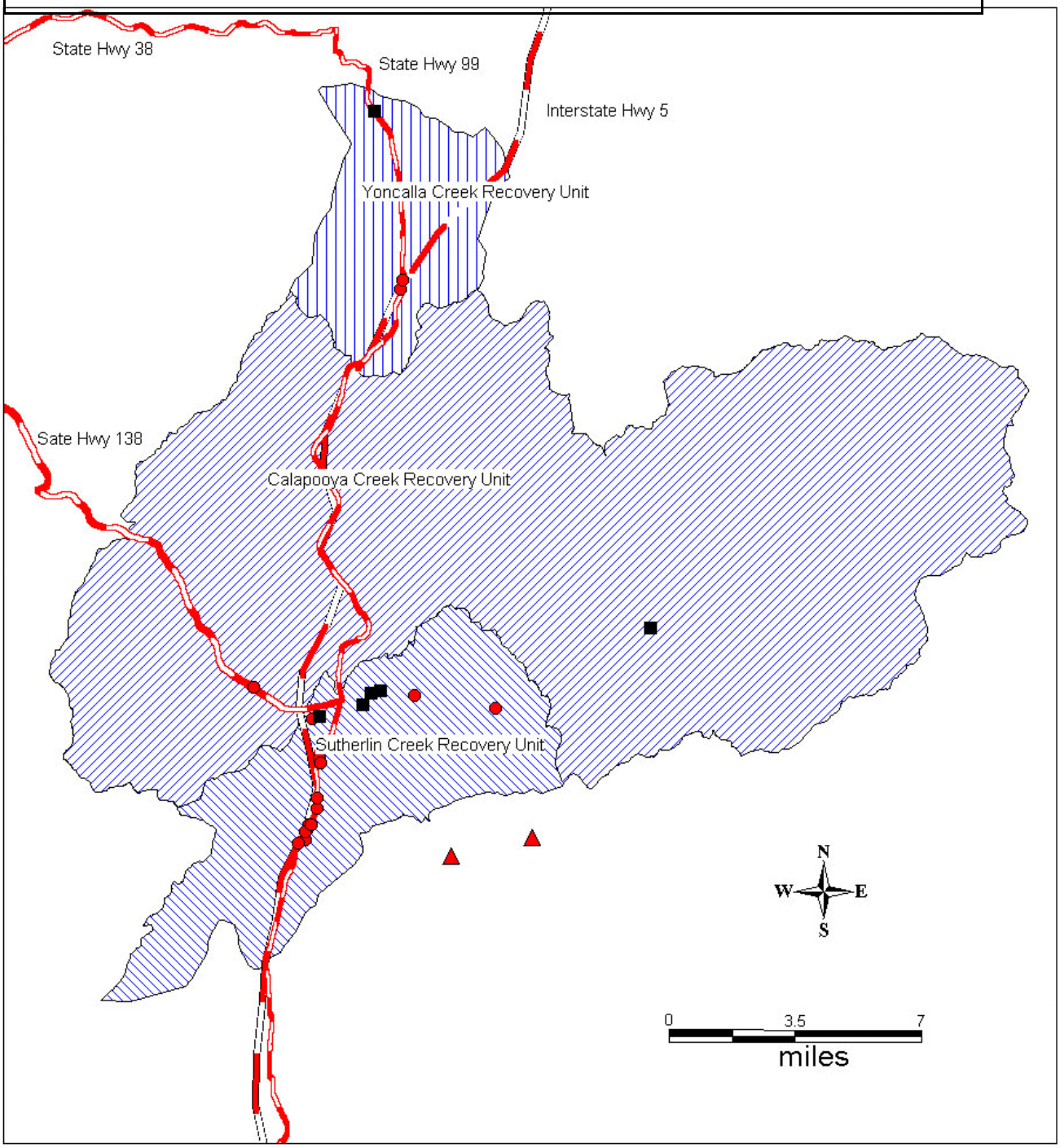
The Calapooya Creek (including Cook Creek) Recovery Unit supports one extant population (EO*014 - public and/or privately owned) and contains the site of an historic collection made in 1932 (EO*003).

The Yoncalla Creek Recovery Unit contains two publicly owned (Oregon Department of Transportation) extant patches (EO *004), and contains the site of an historic collection made in 1939 (EO*002).

The Sutherlin Creek Recovery Unit contains the majority of the extant 14 populations (EO*001, EO*005, EO*007, EO*012, EO*013, EO*015). This area also contains four of the six extirpated population sites (EO*006, EO*007, EO*010, EO* 011), in addition to one small newly created population on private land.

Map 2. Rough popcornflower recovery units corresponding to Yoncalla Creek, Calapooya Creek and Sutherlin Creek watersheds.

- Extant Population
- Extirpated Population
- Introduced populations*



* Bureau of Land Management: North Bank Habitat Management Area

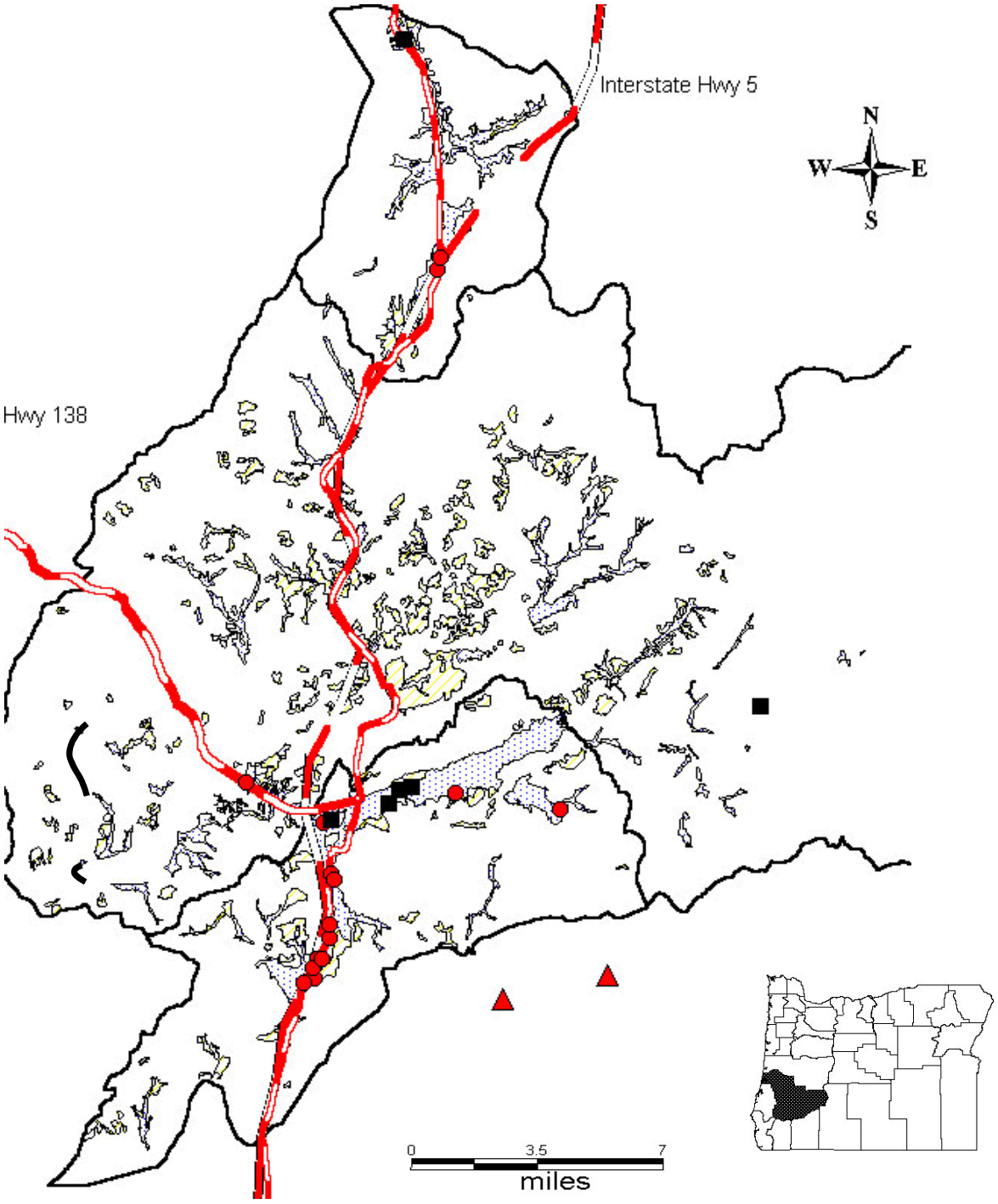
Habitat and Ecology

The rough popcornflower occurs only in seasonal wet meadows where it typically remains submerged under standing water from late fall through spring. Seasonal wet meadows or wet prairies include some aspects of "vernal pools." Like wet meadows, vernal pools are seasonal wetlands that form only in regions where specialized soil and climatic conditions exist. They both can occur in regions where downward percolation of rain water is prevented by the presence of an impervious hard pan or clay pan layer. While soils of wet meadows have soils that are generally deep, vernal pool soils are typically shallow over a claypan or hardpan. The soil depth of Conser soils series can attain a depth of over 160 centimeters (63 inches).

The majority of extant and extirpated sites occur on the Conser silty clay loam soil series (Appendix 2) which are deep, poorly drained soils present in depressions in alluvial stream terraces (Natural Resources Conservation Service 2000). An apparent water table is at its uppermost limit within these soils from November to May, the height of the wet season (Shafer 1996). At this point, the soils are usually fully saturated. The plant also appears on the Brand soil series which are poorly drained soils in low stream terraces with apparent water tables at or near the soil surface from November to May (Natural Resources Conservation Service 1997a, Natural Resources Conservation Service 2000). Several other soil series are occasionally associated with the plant; most are poorly drained flood plain soils. Map 3 shows distribution of potential habitat within recovery units based on soil type.

The rough popcornflower often occurs in dense, monospecific groups in the deepest portion of the shallow pools in which it resides. Associated species occurring along the immediate periphery of rough popcornflower populations are typical of sedge/grass-dominated open marsh. Native herbaceous associates include green-sheathed sedge (*Carex feta),* clustered sedge (*C. arcta),* one-sided sedge (*C. unilateralis*), common rush (*Juncus effusus*)*,* pointed rush (*J. oxymeris),* tapered rush (*J. acuminatus*), western mannagrass *(Glyceria occidentalis),* sloughgrass (*Beckmannia syzigachne*), tufted hairgrass (*Deschampsia caespitosa*), and great white camas (*Camassia leichtlinii*). Annuals present in these sites

Map 3. Rough popcornflower potential habitat within recovery units



* Bureau of Land Management: North Bank Habitat Management Area

include skullcap speedwell (*Veronica scutellata*), Willamette downingia (*Downingia yina*), and Douglas' meadow-foam (*Limnanthes douglasii*). Most sites are moderately to highly disturbed due to agricultural and development activities. Consequently, they are out competed for space and water by infestations of exotic weeds, including teasel (*Dipsacus sylvestris*) and pennyroyal (*Mentha pulegium*).

Oregon oak (*Quercus garryana*) and Oregon ash (*Fraxinus latifolia*), as well as introduced pears (*Pyrus* spp.) And English hawthorn (*Crataegus monogyna*), exist on the perimeters of some pools, but the rough popcornflower usually does not favor the shaded understories of these sites. Populations at the Popcorn Swale Preserve (EO*009) that persist in the understory of ash and pear trees are not typical of the species as a whole. The populations there generally have lower fecundity, a smaller stature and are more dispersed than populations occurring elsewhere (Amsberry 2003). Both circumstantial and experimental evidence suggest that shading diminishes the vigor and reproductive capacity of the rough popcornflower, and reduces seedling recruitment and establishment (Amsberry and Meinke 1999). Before European settlement, sites were probably kept open by periodic burning due to fires purposefully set by Native Americans, or occurring naturally from lightning strikes (Johannessen *et al.* 1971).

The interaction of the rough popcornflower and other organisms present in its ecosystem has not yet been well-studied. Caterpillars and aphids have been observed eating foliage and flowers of the rough popcornflower, and plants showing evidence of herbivory by deer and small rodents have also been documented. Beetles use the flowers for breeding platforms, and spiders are often seen hunting in the dense foliage in summer. Native ctenuchid moths (*Ctenucha*) are seen consistently on the plants throughout the spring and summer, and have been observed obtaining nectar from the flowers, but the importance of the flower to the moth, or vice versa, is not known.

Life History and Demography

The rough popcornflower has an annual or short-lived perennial life history. Seeds are dispersed as they mature in summer and fall, and begin to

germinate with the initiation of fall rains. In the greenhouse, 65 to 95 percent of field- collected seed from 10 populations throughout Douglas County germinated within 5 days, provided the germination medium was adequately moist and seeds were submerged (K. Amsberry, pers. comm. 2003a). After nearly 30 days, the range of survivorship for each population was between 20 and 100 percent with a mean of 66 percent (Amsberry and Meinke 2002). Germination ranges from poor to prolific in the field, with zero to 78 seedlings present per 10 square centimeter (1.55 square inch) plots after natural seed dispersal from introduced plants at the North Bank Habitat Management Area. Seedling mortality in these plots was quite high; a 26 to 65 percent mortality was observed within the first month after germination. In the field, intraspecific competition, damage due to uprooting by seasonally rapid stream flows, and other random naturally occurring events contributed to the high levels of mortality observed. Based on these observations, seed maturation and recruitment over 1 month in natural populations probably averages between 30 and 50 percent.

Those seedlings that survive over winter as submerged rosettes, like many seasonally aquatic vernal pool plants, exhibit a morphology very different from the adult plants. Immersed plants produce rosettes of glabrous (smooth), terete (round, smooth) leaves with extensive lacunal (cavity or depression) airspace. These submerged rosettes are so distinct from the hirsute (hairy), flattened foliage produced by emergent plants as to be almost unrecognizable as the same species. This type of submerged vegetation (appropriately titled an 'isoetoid' growth form, as it is typified by the wetland plant *Isoetes*) enhances carbon assimilation in wetland habitats, and is common in seasonally aquatic plants (Keeley and Zedler 1998).

As water recedes in later spring, rosettes emerge and begin to develop flowering stems, which elongate and begin to produce flowers. Flowering is indeterminate and continues throughout the summer, with up to 100 flowers produced per flowering stem, but only 3 to 7 flowers open at any one time. From phenology research observations in the field, 80 percent of plants at a given population are typically blooming at the peak of flowering time (Amsberry and Meinke 2002). Plants are self-compatible, but require insects for pollination. A variety of pollinators have been observed on the flower, including ctenuchid

moths (*Ctenucha*), bumble bees (Bombidae), honey bees (Apidae), hover flies (Syrphidae), and butterflies. In the presence of pollinators, four nutlets per flower can be produced, although, due to fruit abortion, less than this number are often observed.

As well as producing flowers, elongating stems on rough popcornflower growing in sufficiently moist conditions root at the nodes, producing large vegetative mats made up of many interconnected, rooted rosettes. As the occupied pools become completely dry, plants begin to go dormant. In less than optimal habitat (*i.e.* shallower, drier pools), plants die as flowering is completed. In pools which retain moisture, plants are reduced to a series of small rosettes, but remain green throughout the fall. As pools reform with the advent of winter rains, plants become submerged, and adapt their morphology to function as aquatics. During the winter, connecting internodes between rosettes rot away, leaving a series of independent, but genetically identical individuals. Established rough popcornflower populations in most sites are made up of both perennial ramets (elongated stems with rooted nodes) and first year seedlings.

Life history investigations have indicated that a tendency for a perennial life history in this species is both genetically and environmentally controlled. Plants in some populations, most notably those at the Stearn's Lane (EO*014) and Yoncalla Creek Site (EO*004), are much more likely to perennate (remain) than those in others, such as Popcorn Swale (EO*009), even when grown from seed under identical growing conditions in the greenhouse (Amsberry 2001). Other morphological and phenological differences are evident among populations of the rough popcornflower, indicating the existence of significant genetic variation among populations. In the greenhouse, plants grown from seed collected at Popcorn Swale (EO*009) and the Hawthorne Street Site (EO*007) begin to bloom 2 to 3 weeks before those grown from seed collected at Stearn's Lane (EO*014) and the Yoncalla Creek (EO*004) sites. In created populations made up of greenhouse-grown plants from various sources, the number of flowers produced per plant, as well as the numbers of flowers per inflorescence, varied significantly among plants grown from three seed sources (Amsberry and Meinke 1999). Phenotypic variation is not unexpected among plant populations, even in the presence of (a limited level) gene flow (Levin 1993). As naturally occurring

populations are clustered on three distinct stream basins (recovery units one through three), gene flow among these clusters has probably always been limited, maintaining variation and promoting population differentiation through genetic drift or selection. Potential gene flow among formerly interbreeding plant populations would likely become further restricted due to the fragmentation of habitat and restriction of pollinator types. This could advance the fixation of adaptive or random traits (Barrett and Kohn 1991).

Reasons for Listing

A. The present or threatened destruction, modification, or curtailment of habitat or range. Land use patterns since the time of European settlement have greatly influenced vegetation patterns throughout the West, and habitat destruction has been of particular importance to the loss of vernal pool and seasonal wet meadow species. Conversion of wet meadows to agricultural use was identified as a major contributor to the extinction of vernal pool species as early as 1941 (Hoover 1941), and researchers currently estimate that 60 to 90 percent of pools extant at the time of European settlement have now been destroyed, along with the endemic plant and animal species associated with them (Keeley and Zedler 1998; King 1998). In the Umpqua Valley, conversion of wet meadows to agricultural use through hydrological alterations has drastically reduced the number of seasonal wetlands that can support the rough popcornflower. Even within areas that have escaped wholesale destruction due to development or agriculture, changes in land management practices in neighboring wetlands have altered the nature of remaining swales. Draining of adjacent land has affected swale depth and size, reducing the suitability of these habitats for the rough popcornflower.

In addition to filling and draining, wet meadows have also been modified to the point of unsuitability for the rough popcornflower by other land management practices. Fire exclusion since the time of European settlement has drastically altered vegetation successional patterns in seasonal wetlands (Johannessen *et al*. 1971). Increasing shade due to canopy closure over swales that were previously kept open by fire has reduced suitability for the rough popcornflower, and encroachment of competing native and exotic wetland

vegetation has decreased the vigor and viability of existing populations. Unmanaged grazing by domestic livestock, especially by sheep, has likely caused site specific extirpation of plants and damaged wetland integrity and stability (Amsberry and Meinke 2002).

Despite the negative effects of agriculture, the most devastating impact to the rough popcornflower was probably specifically the channelization of Sutherlin Creek and subsequent development of rough popcornflower habitat. The rapid human population increase, and subsequent urban expansion, in the Sutherlin area is likely, but not necessarily a contributing factor to the recent development. The potential for further development of rough popcornflower habitat remains the most severe threat. Sutherlin experienced a 3.8 percent annual growth rate from 1990 to 2000, one of the most rapid rates in the nation (Oregon Economic and Community Development Department 2003). This rapid growth rate, in a city built almost entirely within the historic floodplain and terrace of Sutherlin Creek, has resulted in the filling and draining of wetlands for residential and commercial development at an unprecedented pace. Four populations of the rough popcornflower within the boundaries of Sutherlin-Hawthorne 1 (EO*007), Horsepasture 1 (EO*010),Waite Road (EO*006), and Sheep Meadow (EO*011) - have been lost to residential development within the last 5 years. Additionally, Hawthorne 2 [EO*007], previously the largest known population of rough popcornflower, has been extirpated due to illegal filling and draining for construction of a self-storage complex. A newly created 6 foot deep channel adjacent to the site now effectively drains water from the site (S. Friedman, pers. comm. 2003). Recovery Criteria numbers 1, 2, and 3, when accomplished, will reduce threats from destruction and modification of habitat.

B. Overutilization for commercial, recreational, scientific, or educational purposes. The rough popcornflower is not known to be collected for any purpose. However, plants could potentially be collected for horticultural use, or to be tested for medicinal compounds. As this species is difficult to distinguish from other members of its genus, the initiation of large-scale collecting of any species of *Plagiobothrys* could result in accidental collection of the rough popcornflower. A more likely threat, however, is purposeful destruction of plants and their habitat. Several incidents of intentional destruction of suitable habitat in

the Sutherlin area have been documented, both by farmers who are concerned that their ability to farm will be curtailed by the presence of the rough popcornflower on their land, and by developers concerned that they will not be able to develop their property. No threats were documented for collection of plants however, Recovery Criteria numbers 1, 2, and 3, when accomplished, will reduce threats from purposeful destruction of plants and their habitats.

C. Disease or predation. Aphids may limit seed set by damaging inflorescences and reducing pollinator visitation, although the high seed set recorded in natural and experimental populations (up to 8,000 seeds/plant) indicates that aphid damage does not routinely have a dramatic impact on seed production (Amsberry and Meinke 1999, Amsberry 2001). Size of aphid populations vary greatly among rough popcornflower populations and among years, and seem to be adequately restrained by natural controls. Deer, caterpillar, and rodent herbivory have been occasionally reported from most sites. The small amount of biomass removed by this type of herbivory appears to have little or no effect on plant growth or fecundity.

Grazing by domestic sheep and cattle appears to negatively affect populations of the rough popcornflower. Populations present in fields where extensive grazing occurs are reduced to a few plants subsisting in and under patches of rush (*Juncus patens* and *J. oxymeris*) patches and not usually grazed by cattle, although in ungrazed fields plants prefer open areas away from rush clumps. However, populations in fields with limited grazing, especially by horses, appear to be growing well and reproducing prolifically (K. Amsberry, pers. comm. 2003a). Limited grazing may, to some extent, mimic the biomass removal aspects of natural disturbances such as fire, and has the potential to be used as a management tool to maintain rough popcornflower habitat. However, acceptable grazing practices such as rest/rotation or a minimal density of cattle per acre should be clarified along with the optimal regimes before grazing be recommended as a tool (Natural Resources Conservation Service 1997b). No recovery criteria were developed for insect predation since this is not a significant threat. However, Recovery Criteria numbers 1, 2, and 3, when accomplished, will reduce threats from grazing of domestic sheep and cattle.

D. Inadequacy of existing regulatory mechanisms. The rough popcornflower is listed as endangered by the State of Oregon (OAR 603-73-011-010). However, State law does not protect listed plants when they occur on private land, and so has little effect on the majority of rough popcornflower sites. These plants are afforded a certain level of protection because they are hydrophytic (typically found in wetlands) and wetlands are regulated as waters of the State under Oregon's Removal-Fill Law (ORS 196.800-196.990), and as waters of the United States under section 404 of the Clean Water Act. Therefore, both State and Federal permits are required to fill or drain wetlands in Oregon. Nevertheless, from a practical standpoint, farm use exemptions combined with a "Federal nationwide permit program" contribute to significant cumulative wetland losses and degradation. Also, as administered by the Oregon Division of State Lands and the U.S. Army Corps of Engineers, both the Removal-Fill Law and the Clean Water Act, respectively, allow most permit applicants issuance of their permits. While there are provisions for compensatory mitigation under both the State and Federal authorities, the track record for mitigation success is low. In addition, there are a large number of unauthorized activities occurring that further the amount of wetland loss and degradation. According to information provided by the Oregon Division of State Lands, wetland fill compliance rates from 1999 through 2002 remained low (30 to 35 percent). This low compliance rate can be partially explained by the fact that compensatory mitigation is very detailed and complex. Failure to follow any part of the compensatory mitigation plan results in a site being non-compliant (S. Morrow, pers. comm. 2003). Additionally, because of limited staff resources, Oregon Division of State Lands and the U.S. Army Corps of Engineers are only able to respond to a percentage of the wetland fill violations reported annually. Subsequently, enforcement actions are confined to a relatively small percentage of the total number of violations and the successes of the actions applied are largely dependent on voluntary compliance.

Since permitting under section 404 of the Clean Water Act constitutes a Federal action (by the U.S. Army Corps of Engineers), there is a Federal nexus for section 7 consultation under the Endangered Species Act. However, the Endangered Species Act does not allow a provision for the take of plants. Unless the proposed wetland fill activity will result in jeopardy to a listed species, in this case the rough popcornflower, the action can not be denied. Recovery Criteria

numbers 1, 2, and 3, when accomplished, will reduce threats from fills and thus provide protection from inadequate regulatory mechanisms.

E. Other natural or manmade factors affecting its continued existence. Other than habitat destruction, competitive exclusion from native and nonnative wetland vegetation probably represents the most significant ongoing threat to the rough popcornflower. Pennyroyal (an exotic) and rushes (native) compete directly with the rough popcornflower and appear to reduce plant size, fecundity, and especially seedling establishment. Severely invasive exotics, such as teasel (*Dipsacus fullonum*) and meadow knapweed (*Centaurea debeauxii*) can completely choke wet meadow habitat, eliminating native plants and reducing wetland functions. Transplants of the rough popcornflower establish better with vegetation removal (research in progress), as have other studies of transplant success and seedling recruitment in relation to vegetation removal (Carslen *et al.* 2000, Pendergrass *et al.* 1999).

Because the administratively protected populations (two patches owned by Oregon Department of Transportation; EO*004, and three by The Nature Conservancy; EO*009) are adjacent to roadways (I-5 and County Road 338), the potential for chemical spills due to highway accidents is a conceivable threat to the rough popcornflower. An accident of this type, although unlikely, could easily destroy a large portion of the protected populations. Accidental herbicide spraying as part of routine highway maintenance is also a possibility, although Oregon Department of Transportation's commitment to the rough popcornflower conservation makes this scenario unlikely. Privately owned populations near the railroad tracks (the Deady Crossing Sites, Glide Lumber Site, and Horsepature 2 Site- EO* 005, EO*012, EO*001) face a similar potential for destruction due to chemical spills and routine maintenance activities.

Habitat fragmentation is another way in which human intervention on the landscape has negatively affected the rough popcornflower. The partitioning of a previously contiguous population into a series of isolated smaller ones serves to segregate the formerly large, interbreeding group of plants into a series of independent patches. These smaller, isolated populations no longer interbreed, and experience restricted gene flow, with a subsequent reduction in genetic

variability within populations. Populations below an actual size of about 5,000 individuals will generally maintain insufficient adaptive genetic variability for evolution to occur, and those below 1,000 individuals will experience the accumulation of deleterious alleles which will ultimately result in population decline. The 5,000 plants represents the 500 plants needed for the effective population size plus additional plants (by a factor of 10) to compensate for small population sizes, ramets, and deleterious alleles. In this case, a rough popcornflower population of 5,000 individuals, should prevent the negative genetic consequences of small population size (Culotta 1995, Lande 1995, Lynch *et al.* 1995). Recovery Criterion number 3, when accomplished, will reduce threats from catastrophic events such as chemical spills because there will be at least three reserves in each recovery unit. Recovery criteria numbers 1, 2, 4, 5, and 6, when accomplished, will reduce threats from habitat fragmentation, competition, and small population size.

Past and Current Conservation Measures

Conservation measures, including regulatory protection, land management plans, inventory of existing populations, and a series of research projects (including the creation of new populations) have been developed by various agencies. Listings of the rough popcornflower as endangered by us and the Oregon Department of Agriculture provide regulatory protection for extant populations of the rough popcornflower on Federal and State lands.

Land management plans promoting the persistence of extant rough popcornflower populations have been developed by Oregon Department of Transportation and The Nature Conservancy. The Yoncalla Creek patches (EO*004) are managed by Oregon Department of Transportation as a Special Management Unit - these populations are mowed as part of a regular maintenance regime only in late summer to prevent damage to actively growing or reproducing plants. Other maintenance activities (such as spraying or ditching) are prohibited within this site. Removal of, or damage to, rough popcornflower plants is prohibited. The Nature Conservancy actively manages for viability of the rough popcornflower within the Popcorn Swale Preserve (EO*009). Weedy competitors are removed on a regular basis, and populations are monitored annually to evaluate population status (D. Borgias, pers. comm. 2000).

Several inventories for new populations have been completed, including a thorough search of the Sutherlin area by James Kagan (Oregon Natural Heritage Program) in the early 1980's, and a more recent survey by the Oregon Department of Agriculture in 1998. Surveys are generally confined to roadsides, as most rough popcornflower habitat is in private ownership. A record of all known populations is maintained by the Oregon Natural Heritage Program, and is updated as new information is provided. Although anecdotal reports of new populations are frequently related, follow-up searches in response to these reports have not often been fruitful. The difficulty in identifying this species, and especially its similarity to the fragrant popcornflower makes identification of this species by amateurs problematic. Public outreach efforts such as the Glide Wildflower Show provide an opportunity to display the two species, and educate the public on identification and conservation issues related to the rough popcornflower.

As little published research on the rough popcornflower had been completed prior to 1995, recent cooperative projects by the Oregon Department of Agriculture, Oregon State University, and the Service on population-level genotype variation, reproductive biology, and life history traits have provided valuable information on the biology and ecology of this rare species. In addition, the elucidation of propagation, cultivation, and transplant requirements have permitted the large scale production of transplants to be used for population creation and reintroduction. A population augmentation project at two sites near Sutherlin, and the creation of two new populations on the North Bank Habitat Management Area, have both been temporarily successful in increasing the potential viability of the rough popcornflower.

Recovery Strategy

The rough popcornflower will be conserved by establishing a network of protected populations in natural habitat distributed throughout its native range. To ensure conservation of currently existing genetic variability, and to prevent random naturally occurring and demographic collapse, the plan requires that a minimum of 3 viable populations of 5,000 individuals be protected within reserves in each of the 3 recovery units. Watersheds are used as a basis for recovery unit distribution, as they are natural units of the landscape, and because

evidence indicates that genetic differentiation may follow watershed boundaries (Amsberry 2001). The strategy for each recovery unit will include rehabilitation of habitat, restoration of extant historic populations, reestablishment of extirpated populations, and experimental establishment of populations in never before occupied potentially suitable habitat. The genetic source for experimental rough popcornflower introductions will correlate to watershed, location, and habitat characteristics of the establishment site.

The importance of individual recovery units to the rough popcornflower relies on providing for the distribution of the species across its native range and maintaining adaptive ability to ensure long-term persistence (Culotta 1995, Lande 1995, Lynch *et al.* 1995). When total population numbers within the recovery unit fall below 5,000 individual rough popcornflower plants, these populations could experience the accumulation of deleterious alleles which ultimately result in population declines and extirpation. In order for the species to survive and recover in the future, all the genetic diversity across the total range of the species must be conserved in order to provide the species with adaptive abilities when the future environments change (Culotta 1995, Lande 1995, Lynch *et al.* 1995). Since each of the recovery units are based on preserving the genetic differentiation across the species range and all genetic diversity currently in the populations is vital to their continued existence, all of these recovery units are necessary for both the survival and recovery of the species. Thus, the loss of all the unique genetic material from one of the recovery units may spell extinction for the species when the environment undergoes a rapid change. Having reached this conclusion, that these recovery units are necessary for both the survival and recovery of the species, we shall consider the effects of proposed Federal actions undergoing section 7 consultation on the recovery unit, rather than on the species as a whole. This means that a jeopardy analyses of a proposed Federal action need only consider the effects to an individual recovery unit and not the wide-ranging effects to the species as a whole (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

To be counted toward the recovery objective, reserves must consistently maintain adequate numbers of viable rough popcornflower plants for a minimum of 5 years. Within the timeframe of 5 years, population numbers may increase and decrease due to seasonal climatic or site specific variation. A trend toward

decreasing numbers may last for one or two seasons, but then should stabilize or begin an increase (Amsberry and Meinke 2002). A downward trend lasting more than 3 years in a population is a cause for alarm and the threats should be examined.

Density is calculated by counting the number of rooted stems/nodes and rosettes present in a 1 square meter (11 square feet) plot. Because this species spreads through vegetative reproduction (adventitious stem rooting), individual, independent plants may not represent genetically distinct individuals (See Recovery Criterion 2). Populations can be periodically monitored by comparing the extent of the current year's occupied habitat to the previous year's extent. This change can be considered a measure of recruitment and it is important to note in each reserve as an important factor towards recovery. Another indication of population health is a measure of reproductive activity. This is most easily observed by measuring the percent of plants blooming in a population during the peak of flowering (June and July). A typical population of rough popcornflower is commonly observed to have 80 percent flowering during the flowering peak. Measures of occupied habitat, combined with density, recruitment and phenology, provide a practical method for evaluating the viability of both extant, reestablished, and newly created populations.

Both extant, historic, reestablished, and newly created populations will require management. Encroaching vegetation must be controlled, and populations may require periodic augmentation. Various land management regimes should be evaluated for efficiency, and prescribed management adjusted accordingly.

II. RECOVERY

Recovery Objective

The objective of the recovery plan is to reduce the threats and increase population viability of the rough popcornflower to the point that it can be downlisted to threatened status. Implementation of the recovery actions specified in the plan should allow this species to become capable of sustaining itself indefinitely within its historic range. This plan addresses the major threats to the rough popcornflower, and recommends actions to reduce or eliminate these threats: habitat destruction and fragmentation will no longer occur within protected reserves, appropriate management plans will not allow unmanaged grazing or other detrimental actions (such as channel incision), and encroaching vegetation will be controlled or removed.

Criteria for reclassification to threatened status.

The rough popcornflower should be considered for downlisting to threatened when all of the following recovery criteria are met:

1. At least 9 reserves, containing a minimum of 5,000 plants each, are protected and managed to assure their long-term survival.

2. A minimum of 1,000 square meters (10,764 square feet) are occupied by the rough popcornflower within each reserve, with at least 50 square meters (538 square feet) having a density of 100 plants/square meter (100 plants/11 square feet) or greater. "Occupied habitat" is determined based on a vegetation sampling procedure using 1 meter x 1 meter (3.3 foot x 3.3 foot) plots that are scored for the presence or absence of the rough popcornflower. Density is calculated by counting the number of rooted stems/nodes and rosettes present in a 1 square meter (11 square foot) plot. This can be facilitated by using 0.1 by 0.1 meter (3.9 inch x 3.9 inch) subplots and estimating density of metric square based on cover (K. Amsberry, pers. comm. 2003a). Due to the clonal nature of the rough popcornflower, independent stems can be considered "ramets," and may not represent genetic individuals.

3. A minimum of nine reserves are distributed among the three natural recovery units (Calapooya Creek, Sutherlin Creek, Yoncalla Creek), with at least three reserves present in each unit.

4. Patches contained in each reserve are within 1 kilometer (0.6 mile) (Levin 1993) of each other to allow pollinator movement and gene flow among them. Patches are designed to include as much suitable habitat as possible especially if currently occupied by rough popcornflower.

5. Five years of demographic data indicate that populations in at least seven of the nine reserves within the three recovery units have average population numbers that are stable or increasing, without decreasing trends lasting more than 2 years.

6. Seventy-five percent or more of the plants are reproductive each year, with 30 percent annual seed maturation and recruitment evident in all populations.

Appendix 3 links recovery criteria to the five listing factors and recovery actions.

The total size of a reserve will be considerably larger than its area of occupied, suitable habitat, and each reserve will contain multiple patches of the rough popcornflower. Populations of this species may move into and out of suitable habitat, requiring that available habitat surrounding existing or created patches be kept in suitable condition to allow for frequent colonization, abandonment, and re-colonization of these areas.

The rough popcornflower is not delistable unless viable natural occurrences meeting the six recovery criteria in the native habitat can be secured and protected. Specific criteria for delisting cannot be developed until the natural occurrences meeting these conditions are identified and protected.

Step Down Outline of Recovery Actions

1. Conserve and manage a minimum of nine reserves within three recovery units.
    - 1.1 Conserve existing patches within recovery units.
        - 1.1.1 Evaluate the status of all existing populations.
        - 1.1.2 Conduct surveys to search for new populations.
        - 1.1.3 Select and delineate reserve sites.
        - 1.1.4 Protect habitat to be included in reserves.
        - 1.1.5 Improve management of existing sites.
            - 1.1.5.1 Provide educational opportunities for landowners/managers.
            - 1.1.5.2 Use of existing authorities and applicable regulations.
            - 1.1.5.3 Reduce competition and reduce impacts of succession from native and nonnative competitors.
                - 1.1.5.3.1 Evaluate techniques to reduce competition from native and nonnative species.
                - 1.1.5.3.2 Evaluate techniques to reduce impacts of woody succession from native and nonnative species.
                - 1.1.5.3.3 Implement control measures.
            - 1.1.5.4 Augment size of existing populations.
                - 1.1.5.4.1 Collect seeds from extant sites.
                - 1.1.5.4.2 Produce and establish transplants.
            - 1.1.5.5 Monitor existing populations.
    - 1.2 Develop new protected populations in each recovery unit.
        - 1.2.1 Select appropriate sites for new populations.
            - 1.2.1.1 Identify ecologically appropriate habitat.
            - 1.2.1.2 Protect population introduction sites.
        - 1.2.2 Collect seeds.
        - 1.2.3 Produce and establish transplants.
        - 1.2.4 Manage populations to promote viability.
        - 1.2.5 Monitor new populations to determine viability.
2. Ex-situ conservation.
    - 2.1 Rank populations.

2.2 Collect and bank seeds.

3. Research factors that threaten the recovery of the species.
    3.1 Evaluate population genetic diversity.
    3.2 Evaluate the availability of pollinators.
4. Provide outreach services for owners of reserve populations and the general public.

Narrative Outline of Recovery Actions

1. Conserve and manage a minimum of nine reserves within three recovery units. All extant populations of the rough popcornflower are fragmented and subject to disturbance and probable extirpation. In order to reverse the current downward trend for this species, and ensure its recovery, at least nine reserves, distributed within the three natural recovery units, should be conserved and managed for the long-term viability of the species. Protection of these reserves can be accomplished by conservation agreements or partnerships with current landowners, land acquisition, and integration of conservation priorities into land use planning by local agencies such as the City of Sutherlin.

To maximize genetic and ecological variation in the rough popcornflower, and reduce its vulnerability to random events, reserves should be distributed among three natural recovery units. The three natural units are located along three sub-basins of the North Umpqua River: Yoncalla Creek, Calapooya Creek (including Cook Creek), and Sutherlin Creek.

The Yoncalla Creek Recovery Unit currently supports two extant patches (EO*004), the only ones on publicly owned land (Oregon Department of Transportation, Roseburg, Oregon). Plants in this population are morphologically distinct from those in other populations, as they are generally larger than other plants, and have a greater tendency to exhibit a perennial life history (Amsberry 2001). Herbarium collections from an extirpated site on Yoncalla Creek (EO*002) also exhibit this larger, more perennial-appearing morphology, indicating that plants growing along this watershed may represent a genetically distinct group. This possible genetic distinctiveness, combined with their location at the far north end of the range for the rough popcornflower, makes these populations especially worthy of conservation (Lesica and Allendorff 1995). As

these two patches are close enough to interbreed and contain more than 5,000 plants between them, they constitute the basis for one reserve. This recovery unit must contain at least three reserves, requiring the creation of new populations in two new protected reserves.

The Calapooya Creek Recovery Unit currently supports one extant patch (Stearn's Lane, EO*014). An extirpated site east of Sutherlin (represented by Cole's 1932 collection at Nonpareil, EO*003) is also located along Calapooya Creek. Although these two populations are currently too distant from each other to interbreed, undocumented intermediary populations may have once existed along this watershed, allowing gene flow among these sites to occur. The Stearn's Lane population is currently very small (less than 0.2 hectare [0.5 acre] and 500 plants) and isolated from other populations. As the population is within a few meters of Stearn's Lane (a Douglas County maintained road), it is at least partly on public land and is nominally protected. Augmentation of this population, as well as clarification of its ownership and protection, will be necessary if it is to be included as a reserve population. The additional protected populations must be near enough to each other to interbreed. The area around Ford's Pond has been suggested as an appropriate site for the creation of new populations of the rough popcornflower (M. Sullivan, pers. comm. 2000), and may meet the administrative and ecological criteria to be incorporated into a reserve. The Calapooya Creek Recovery Unit must support three reserves on protected land.

The Sutherlin Creek Recovery Unit contains the remainder of the extant and extirpated patches (18), and makes up the central core of the rough popcornflower's range. At least 3 of the 18 patches are within The Nature Conservancy's Popcorn Swale Preserve where they are protected and managed. A progression of patches stretching north from Popcorn Swale to Sutherlin currently exists, creating a series of interbreeding populations which can fill appropriate habitat as it becomes available. A created population also exists within this unit as part of a wetland mitigation project (J. Barnes, pers. comm. 2000).

Protection of these existing patches, as well as the currently unoccupied habitat between them, is of paramount importance to successful recovery of the species. These intermediary populations are currently privately owned. Securing these sites through acquisition, conservation agreements, and other means is a priority for recovery. Extirpated and extant sites within and around the City of Sutherlin should also be protected. Four populations in this unit have been lost since 1995, resulting in a serious reduction in viability of the species. The remaining extant sites (part of the Hawthorne Road Site [EO*007], Southside Road [EO*015], and Sutherlin 1 [EO*001]) should be protected as part of the City of Sutherlin's urban development plan. Populations within at least three reserves must be protected in this recovery unit. Development of more than three reserves would promote stability of this species.

The North Bank Habitat Management Area currently supports two created populations of the rough popcornflower. The genetic source for these experimental populations are from greenhouse transplants of seed collected at all three recovery units. Created in 1998 and 1999, these populations are currently proliferating and appear stable (Amsberry and Meinke 1999). Despite the lack of evidence that the rough popcornflower historically occurred in this site, the administrative protection and beneficial land management practices in this area make these ancillary populations a good choice for refuge in case of catastrophic extirpation of a recovery unit and research studies.

1.1 Conserve existing patches within recovery units. Conservation of all currently extant populations of the rough popcornflower is essential to recovery of this species. Creation of new viable populations is a difficult process, and efforts to recreate populations of rare plants have often been unsuccessful (Allen 1994). Consideration of suitable habitat and genetic source for plant introductions are critical. Little is known about the ecological needs of the rough popcornflower, and, although our initial efforts have been successful, a better understanding of the plants ecology is needed to ensure created populations can persist. Although reintroducing populations of the rough popcornflower within the three recovery units will be an important component of recovery, these created populations will be considered *in addition* to currently extant populations and not as substitutes for them. Research currently in progress at Oregon

State University indicates that significant genetically-based variation in ecologically important traits such as life history exists among populations; the conservation of genetic material from all extant populations will be needed to conserve the genetic integrity of the species.

1.1.1 Evaluate the status of all existing populations. The purpose of this action is to assemble all available information necessary to make informed decisions about which populations can (or cannot) contribute to the recovery of the species. Population size, threats to viability, landownership, and land management objectives should be determined for all sites. Sites which are being threatened by potential filling and draining of wetlands should be identified.

1.1.2 Conduct surveys to search for new populations. Although several surveys have been completed in the Sutherlin Creek Unit, continued reports of previously unknown populations, combined with the ability of the rough popcornflower to advance and retreat into marginal areas in response to changing habitat conditions, requires further surveys. In order to maximize success, surveys should be done in late-June through mid-July, when plants are in flower.

1.1.3 Select and delineate reserve sites. Reserve sites in the three recovery units will be selected in consultation with private landowners, public agencies, and other interested groups or individuals. The most suitable sites will be selected based on land ownership, site management, and other relevant factors - all currently extant sites should be included in reserves if possible.

Boundaries of selected reserves should be accurately identified to ensure precision and efficiency in habitat acquisition and development. Reserve size, location and boundaries will be determined by land ownership, current and projected management practices, distance between extant populations, and provision for unoccupied habitat to allow for population expansion. Boundaries

should also be designated to promote site security, to allow for maintenance of adjacent areas, and to protect hydrologic integrity of protected populations.

Once reserve boundaries have been identified, they should be accurately depicted on aerial photos, large scale topographic maps, and accessible geographic information data bases. Boundaries should also be clearly marked in the field to avoid unintentional disturbance of rough popcornflower populations.

1.1.4 Protect habitat to be included in reserves. All extant populations will be needed as key components of the projected series of interbreeding patches, as well as serving as seed sources for recreating this network of viable populations. The populations within the Sutherlin Creek Unit are especially significant, as they form an interconnected series of populations that can interbreed, and constitute the central core of the species' range. Conservation of larger populations (such as Horsepasture 2, The Nature Conservancy's Popcorn Swale Preserve [EO*009], Deady Crossing South [EO*012], and Oregon Department of Transportation's Yoncalla Creek populations [EO*004]) is a top priority as these can serve as seed sources for both human mediated and natural dispersal into available habitat. Conserving peripheral populations is also important because their isolation may indicate that they are genetically divergent from their neighbors, thereby contributing to within-species genetic diversity, and providing an opportunity for the species to evolve (Lesica and Allendorf 1995).

In order to reliably provide for the recovery and long-term survival of the rough popcornflower, naturally occurring sites on private lands must be permanently protected. This can be done through acquisition by groups interested in rough popcornflower recovery, conservation agreements, mitigation banking agreements, and easements with landowners. Naturally occurring sites on public lands may be protected by management plans, conservation

agreements, and establishment of populations within wetland mitigation sites monitored by the U.S. Army Corps of Engineers and Oregon Division of State Lands.

1.1.5 Improve management of existing sites. Removal of the threats of development and habitat destruction alone will not provide for the recovery of the rough popcornflower. Land management practices since the time of European settlement have greatly altered wet meadow ecosystems, and active management of sites which support this species will be necessary.

1.1.5.1 Provide education opportunities for landowners/managers. Appropriate strategies for managing the rough popcornflower will depend on the goals of the managers at each site. Integration of managers' current goals with rough popcornflower recovery will ensure that recovery objectives outlined in this recovery plan will be met. This species tolerates some disturbance, and naturally grows in dense patches within fairly restricted areas. Due to these ecological traits, many types of agriculture, and in some cases even development plans, can be modified to promote rough popcornflower viability, while still allowing these uses to continue.

Many extant populations in the Sutherlin Creek Unit (other than those owned by The Nature Conservancy) currently suffer from damage due to domestic animals. Cattle and sheep graze rough popcornflower plants, and trampling damages wet meadow habitat. Reduction in grazing pressure can be expected to improve the viability of populations of this species, and would be especially beneficial in sites which currently support scattered patches of rough popcornflower plants (*i.e.* the Wilbur and Deady Crossing Sites - EO*005, EO*012). However, the reduction in the biomass of competitive vegetation produced by appropriate levels of grazing may also

promote rough popcornflower reproduction and recruitment. Determination of optimal levels of grazing, and subsequent dissemination of this information to land managers, will help with the development of acceptable management plans.

1.1.5.2 Use of existing authorities and applicable regulations. Efforts by municipalities, County, State, and Federal entities to use existing authorities should be explored. For example, to secure known and potential wetland habitats, wetland conservation plans under Oregon Division of State Lands, special area management plans under the U.S. Army Corps of Engineers, and local zoning and land use planning under county and city planning departments all can play a role in conserving this species and its associated habitats. The City of Sutherlin has funded a local wetlands inventory to address State-wide Planning Goal 5 Guidelines. The project was funded, in part, by the Oregon Division of State Lands. We contributed towards a concurrent inventory of potential habitat for the rough popcornflower (Farrell *et al.* 2001). Information from this inventory could lead to the development of a conservation planning (a wetland conservation plan or special area management plan) effort using existing authorities to conserve the rough popcornflower. Use of the U.S. Army Corps of Engineers existing regulatory authorities under section 404 of the Clean Water Act and under section 7(a)(1) and 7(a)(2) of the Endangered Species Act should be pursued.

1.1.5.3 Reduce competition and reduce impacts of succession from native and nonnative species. Burning probably occurred historically in the Umpqua Valley. In the absence of a regular fire regime, some form of vegetation removal will be necessary to prevent encroachment at rough popcornflower sites. Removal of

competing vegetation has been instigated at The Nature Conservancy's Popcorn Swale Preserve (EO*009)(D. Borgias, pers. comm. 2000), and has always been part of Oregon Department of Transportation's management at the Yoncalla Creek Site (EO*004). Mowing appears to have been successful in preventing encroachment at this site, and may have contributed to the former vigor of the Hawthorne Road Sites (EO*007). Mowing should take place in late summer, after maturation and dispersal of seeds. Carefully controlled grazing should be evaluated as a potential mechanism for vegetation removal. Mowing, burning, and controlled grazing are three methods which merit further study to evaluate their efficacy in removing encroaching vegetation, and their effects on rough popcornflower plants and seeds.

1.1.5.3.1 Evaluate techniques to reduce competition from native and nonnative species. Plots should be established to assist in evaluation of burning, mowing, grazing, and vegetation removal techniques for removing competition. Plots should be of sufficient size to represent conditions in treatment areas and allow for the basic ecological needs of the rough popcornflower.

1.1.5.3.2 Evaluate techniques to reduce impacts of woody succession from native and nonnative species. Succession of the rough popcornflower's wet meadow habitat to ash/oak woodland in the absence of fire must be prevented. Trees should be removed as they develop, as this species does poorly in shaded areas (Amsberry and Meinke 1999). Plots should be established to assist in evaluating burning, mowing, grazing, and vegetation removal techniques to control woody succession.

1.1.5.3.3 Implement control measures. Based on information gained from actions 1.1.5.3.1 and 1.1.5.3.2, implement appropriate management to reduce competition and control woody plant succession.

1.1.5.4 Augment size of extant populations. Extant populations may require population augmentation as well as habitat improvement to reach the minimum required population size.

1.1.5.4.1 Collect seed from extant sites. Plants to be used for population augmentation should be grown only from seeds collected from within that population in order to preserve any locally adapted genotypes that may occur, and to avoid outbreeding depression. Seed should be collected from as many individuals as possible in order to represent the range of genetic diversity present. Seeds from each individual should be labeled and stored separately (Guerrant 1996). Seeds should be collected when ripe (dark brown or black) - generally in July through September. Due to their indeterminate growth form, individual plants of the rough popcornflower produce seed for an extended period. Providing that seed is collected carefully, without damaging inflorescences, plants will continue to develop after the seed collection process is complete, and will produce seed to be dispersed naturally within the collection site.

1.1.5.4.2 Produce and establish transplants. Transplants have been successfully produced and established in new populations at the North Bank Habitat Management Area (Amsberry and Meinke

1999, Amsberry 2001). Two years after initial transplanting of 1,500 plants, over 5,000 plants are currently persisting in 2 areas at this site, with reproduction of original transplants and recruitment of new seedlings occurring. Plants are not difficult to grow from seed in the greenhouse, and increase rapidly when transplanted into appropriate habitat. Seeds germinate within a few days on moist media without pretreatment, and grow vigorously under standard greenhouse conditions (although care must be taken to avoid infestations by aphids). To avoid the need for supplemental watering, transplanting of potted nonflowering rosettes should be done in April.

1.1.5.5 Monitor existing populations. All currently extant populations should be periodically monitored for population size, number of individuals, percent reproduction and recruitment, and mapped extent and estimate of occupied area. Monitoring should be completed at least once per year, and should include those populations on private land. Landowner outreach and education opportunities (actions 1.1.5.1 and 4) should include opportunities for population monitoring by the landowner, or by outside interested parties.

1.2 Develop new protected populations in each recovery unit.
Replacing a rare species in sites from which it has been extirpated (and restoring suitable conditions to allow it to perpetuate) reestablishes a potentially important component of the original community for those sites, and promotes restoration of functioning ecosystems (Lande 1988). Introduction of populations into new or historic sites within the general locality of established native populations, and augmentation of existing populations, also improves the demographic dynamics of the species as a whole. In the event of extirpation of some populations due to a catastrophic event, surviving populations can serve as seed sources to

reestablish new populations into vacated sites, naturally, or by human-mediated seed dispersal (Menges 1991). A larger number of populations also allows for the development of increased genetic differentiation among sites, increasing overall heritable diversity, and providing more chances for the species to evolve in response to varying selective pressures (Huenneke 1991). As fragmentation of populations has been shown to interrupt pollinator movement, in some species, and consequently reduce seed set (Jennersten 1988; Agren 1996), reintroducing populations within a network that has been disrupted can improve pollinator services and increase fecundity of existing populations (Huxel and Hastings 1999). Due to the limited number of extant populations, their history of severe decline, and their low chances of long-term survival, the creation of new populations of the rough popcornflower within its historic range will be an important component of its recovery.

1.2.1 Select appropriate sites for new populations. Site selection is one of the most important factors influencing the success of created or reintroduced populations of rare plants. Sites that are biologically appropriate and administratively secure should be chosen (Fiedler and Laven 1996). Each of the three recovery units will require selection of sites for new populations; at least two sites must be chosen within the Yoncalla Creek Unit and two within the Calapooya Creek Unit.

1.2.1.1 Identify ecologically appropriate habitat. Selection of sites likely to support new populations of the rough popcornflower will be based on several factors. Naturally occurring populations of this species are generally associated with specific soil series (Conser, Brand, and Bashaw). Selection of sites on these soil types will maximize the likelihood of successful new populations. Persistent naturally occurring populations exist in shallow swales, with little or no overstory. Use of a plant community composition model developed at Oregon State University (Amsberry 2001) to identify areas

likely to support created populations of the rough popcornflower would expedite successful site selection. An inventory of suitable sites by Pacific Habitat Services is currently in progress (Farrell *et al*. 2001) and still in draft as of June 2003. This study should also be consulted when selecting sites.

1.2.1.2 Protect population introduction sites. In order to reliably provide for the recovery and long-term survival of the rough popcornflower, naturally occurring and created sites must be permanently protected. This can be done through acquisition, conservation agreements, mitigation banking agreements, and easements with landowners. Similarly to natural sites, sites of created populations may be protected on public lands by management plans, by conservation agreements and easements with interested landowners, by establishment of populations within wetland mitigation sites monitored by the U.S. Army Corps of Engineers and Oregon Division of State Lands, or through land acquisition by groups interested in rough popcornflower recovery.

1.2.2 Collect seed. Seeds to be used in the creation of new populations should be collected as soon as possible from all known extant populations. Since research has shown that ecologically important traits vary among populations, collection of seeds from all populations is especially important.

1.2.3 Produce and establish transplants. See Action 1.1.5.4.2 for more information.

1.2.4 Manage populations to promote viability. Management of new populations will probably be necessary to ensure their persistence. See Action 1.1.5 for more information on management improvement.

1.2.5 Monitor new populations to determine viability. See Action 1.1.5.5 for more information.

2. *Ex-situ* conservation. Banking (long-term cryogenic storage) of rough popcornflower seeds is recommended to provide an additional level of security to the recovery efforts. A reserve of banked seeds can be used for future augmentation and reintroduction projects, helping to produce appropriate types and levels of genetic diversity in created and augmented populations. Banked seeds may be used to increase genetic diversity in populations that are believed to be suffering from inbreeding depression, and to replace populations lost through environmental disasters.

2.1 Rank populations. All extant populations should be ranked to expedite seed collection. Seed from populations believed vulnerable to imminent disturbance or destruction should be collected as soon as possible. Populations that represent geographic outliers (*i.e.* the Yoncalla Creek patches - EO*004), and those that represent morphological or phenological variation, should also be a priority for seed collection.

2.2 Collect and bank seeds. As well as being used to create new populations, seed collected for long-term storage should be deposited at the Berry Botanic Garden Seed Bank for Rare and Endangered Plants of the Pacific Northwest, located in Portland, Oregon. See Action 1.1.5.4.1 for more information on seed collection.

3. Research factors that threaten the recovery of the species. Although previously completed research has begun to provide information about the biology of the rough popcornflower, many critical questions remain. Greater understanding of among-population genetic diversity, and study of pollinators are needed. Actions 1.1.5.3.1 and 1.1.5.3.2 recommend undertaking studies to consider development of practical and effective strategies for controlling competing or overstory vegetation.

3.1 Evaluate population genetic diversity. Current research indicates that considerable morphological, ecological, and phenological

differentiation exists among populations (Amsberry and Meinke 2002). Further research to determine the levels of variation, possibly through molecular analysis, would be helpful in evaluating the extent of this differentiation, and would provide information critical to the creation of genetically representative populations.

Research on genetic variation within populations would also be valuable, as this would provide information on the potential for the development of inbreeding depression, and would illuminate population genetic structure. Because the rough popcornflower reproduces asexually through adventitious stem rooting, populations have the potential to be made up largely of clonal ramets, with little or no variation among individuals. However, as plants in naturally occurring and created populations produce large numbers of seeds and seedlings, high levels of variation are also possible. Further information on population structure would assist in developing new populations with genetic structure similar to that of existing patches.

3.2 Evaluate the availability of pollinators. Information is needed on which species are pollinators of the rough popcornflower and the availability of these pollinators. The impacts of various vegetation control methods on the availability of pollinators also need to be evaluated.

4. Provide outreach services for owners of reserve populations and the general public. As recovery progresses, reserve sites are expected to be in a variety of ownerships, and this recovery plan will be effective only with the participation of the public and private landowners with jurisdiction over rough popcornflower populations. Managers should be provided with information on efficient and beneficial management techniques, and assistance with population monitoring, as well as any other information or assistance they require. Public outreach efforts such as the Glide Wildflower Show provide an opportunity to share information and educate the public on identification and conservation issues related to the rough popcornflower.

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IV. IMPLEMENTATION SCHEDULE

The following Implementation Schedule is a guide for meeting the objectives discussed in Part II of this plan. This schedule indicates action priorities, action numbers, brief action descriptions, duration of actions, the responsible agencies, and lastly, estimated costs. These actions, when accomplished, should bring about the recovery of the species and protect its habitat. Priorities in column one of the following implementation schedule are assigned as follows:

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in the species' population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to meet the recovery objective.

Key to Acronyms used in Implementation Schedule:
Annual - Action expected to occur annually until species recovered.
Berry - Berry Botanical Garden
BLM - Bureau of Land Management
CITY - City of Sutherlin
COE - Corps of Engineers
DSL - Oregon Division of State Lands
EPA - U.S. Environmental Protection Agency
FHA - Federal Highway Administration
FWS - Fish and Wildlife Service, Roseburg Field Office or Oregon State Office
ODA - Oregon Department of Agriculture
ODOT - Oregon Department of Transportation
TNC - The Nature Conservancy

Total Cost- Projected cost of each action from start to completion
* - Lead Agency

Implementation Schedule for the Rough Popcornflower Recovery Plan															
Action Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year									
						FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY10
Conserve and manage nine reserves within three recovery units															
1	1.1.1	Evaluate the status of all existing populations	1	FWS*, ODA, ODOT, CITY, TNC	30	30									
1	1.1.2	Conduct surveys to search for new populations	1	FWS*, ODA, ODOT, CITY	30	30									
1	1.1.3	Select and delineate reserve sites	2	FWS*, ODA, BLM, TNC	76		38	38							
1	1.1.4	Protect habitat to be included in reserves	9	FWS*, ODA, BLM, TNC, ODOT, COE, DSL, EPA, CITY	360		40	40	40	40	40	40	40	40	40
1	1.1.5.1	Education opportunities for landowners/ managers	annual	FWS*, ODA, ODOT, CITY	50	5	5	5	5	5	5	5	5	5	5

Implementation Schedule for the Rough Popcornflower Recovery Plan															
Action Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year									
						FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY10
1	1.1.5.2	Use of existing authorities and applicable regulations	Annual	FWS*, ODA, ODOT, DSL, COE, CITY	200	20	20	20	20	20	20	20	20	20	20
2	1.1.5.3.1	Evaluate techniques to reduce competition	3	FWS*, BLM, ODA, ODOT, TNC	30	10	10	10							
2	1.1.5.3.2	Evaluate techniques to reduce impacts of woody succession	3	FWS*, BLM, ODA, ODOT, TNC	30	10	10	10							
2	1.1.5.3.3	Implement control measures	8	FWS*, ODA, BLM, TNC	160			20	20	20	20	20	20	20	20
2	1.1.5.4.1	Collect seeds from extant sites	annual	FWS, ODA*, TNC	50	5	5	5	5	5	5	5	5	5	5
2	1.1.5.4.2	Produce and establish transplants	8	FWS, ODA*	160			20	20	20	20	20	20	20	20

Implementation Schedule for the Rough Popcornflower Recovery Plan															
Action Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year									
						FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY10
2	1.1.5.5	Monitor existing populations	8	FWS*, ODA, BLM, TNC,	320			40	40	40	40	40	40	40	40
Total estimated cost to conserve and manage nine reserves within three recovery units					1,496	110	128	208	150	150	150	150	150	150	150
Develop new protected population in each recovery unit															
2	1.2.1.1	Identify ecologically appropriate habitat	2	FWS*, ODA, TNC	40	20	20								
2	1.2.1.2	Protect population introduction sites	9	FWS*, ODA, COE, DSL, COE, CITY	360		40	40	40	40	40	40	40	40	40
2	1.2.2	Collect seeds	9	ODA	45		5	5	5	5	5	5	5	5	5
2	1.2.3	Produce and establish transplants	9	ODA	180		20	20	20	20	20	20	20	20	20
2	1.2.4	Manage populations to promote viability	9	FWS*, ODA, BLM, TNC, ODOT, FHA	225		25	25	25	25	25	25	25	25	25
2	1.2.5	Monitor new populations to determine viability	8	FWS*, ODA, BLM, TNC, ODOT, FHA	320			40	40	40	40	40	40	40	40

Implementation Schedule for the Rough Popcornflower Recovery Plan															
Action Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party	Total Cost	Cost Estimates, in thousands of dollars per fiscal year									
						FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY10
Total estimated cost to develop new protected populations in each recovery unit					1,170	20	110	130	130	130	130	130	130	130	130
Establish long-term, *ex situ* banking of rough popcornflower seeds															
2	2.1	Rank populations	1	FWS*, ODA	10	10									
2	2.2	Collect and bank seeds	annual	Berry	10	5	5								
Total estimated cost to establish long-term, *ex situ* banking of rough popcornflower seeds					20	15	5								
Research factors that threaten rough popcornflower recovery															
2	3.1	Evaluate population genetic diversity	3	FWS, ODA*	60	20	20	20							
2	3.2	Evaluate pollinator availability	3	FWS*, ODA	60	20	20	20							
Total estimated cost to research factors that threaten rough popcornflower recovery					120	40	40	40							

Implementation Schedule for the Rough Popcornflower Recovery Plan															
Action Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party	Total Cost	**Cost Estimates, in thousands of dollars per fiscal year**									
						FY 1	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY10
Public involvement															
3	4	Provide outreach services for owners of reserve and the general public	annual	FWS*, ODA	50	5	5	5	5	5	5	5	5	5	5
Total estimated cost for public involvement					50	5	5	5	5	5	5	5	5	5	5
Total estimated cost for rough popcornflower recovery implementation actions					2,856	190	288	383	285	285	285	285	285	285	285

Appendix 1. Summary of Known Rough Popcornflower Occurrences

Extant

Site Name	***ORNHP**	**Acreage**	**Recovery Unit**
Hawthorne 2 (Dawn St.)	EO*007	1.67	Sutherlin Creek
Sutherlin 1 (Danny Lang)	EO*001	0.35	Sutherlin Creek
Popcorn 1 (east of road)	EO*009	1.24	Sutherlin Creek
Popcorn 2 (north on west side of road)	EO*009	17.02	Sutherlin Creek
Popcorn 3 (south on west side of road)	EO*009	6.39	Sutherlin Creek
Glide Lumber	EO*012	0.63	Sutherlin Creek
Wilbur north	EO*012	0.16	Sutherlin Creek
Wilbur south	EO*012	0.51	Sutherlin Creek
Deady Crossing north (O&K)	EO*005	0.53	Sutherlin Creek
Deady Crossing	EO*005	0.57	Sutherlin Creek
Deady Crossing south	EO*012	2.48	Sutherlin Creek
Horsepasture 2	**FWS	5.51	Sutherlin Creek
Southside Road	EO*015	~5.5	Sutherlin Creek
Val Street	EO*013	~0.5	Sutherlin Creek
Stearns Lane	EO*014	~0.5	Calapooya Creek
Yoncalla 1	EO*004	1.05	Yoncalla Creek
Yoncalla 2	EO*004	0.51	Yoncalla Creek
Total = 17	**9.5**	**39.12**	

Extirpated

Site Name	***ONHP**	**Acreage**	**Recovery Unit**
Hawthorne 1	EO*007	0.82	Sutherlin Creek
Horsepasture 1 (Lot 18)	EO*010	0.11	Sutherlin Creek
Waite Road	EO*006	0.12	Sutherlin Creek
Sheep meadow (Grove Street)	EO*011	?	Sutherlin Creek
Peck collection	EO*002	?	Yoncalla Creek
Cole collection	EO*003	?	Calapooya Creek
Total = 6	**5.5**	**?**	

*ORNHP = Oregon Natural Heritage Program Element Occurrence Number
**FWS = Fish and Wildlife Service record (U.S. Fish and Wildlife Service 2000)
Acreage = Geographical Information System mapped units of rough popcornflower sites

Population areas were mapped and areas estimated by Oregon Natural Heritage Program and the U.S. Fish and Wildlife Service.

Appendix 2. Soils Chi Square Analysis for Rough Popcornflower

Plagiobothyrus hirtus			Soil types					
	Number of Soils	total micro-cells	15a Bashaw Clay	29a Brand Silty Clay Loam	44a Conser Silty Clay Loam	166c & e Nonpareil Loam	170d Oakland Silt Loam	224b Sibold Fine sandy Loam
Grid location	6	35						
Observed			2	5	21	3	2	2
expected			5.833	5.833	5.833	5.833	5.833	5.833
(Obs-Exp)2/Exp			2.5190476	0.1190476	39.433333	1.3761905	2.5190476	2.5190476
43123C3:AD05					X			
43123C3:AA21							X	
43123C3:AA22						X		
43123C3:AB22						X		
43123C3:AD06					X			
43123C3:AD07				X				
43123C3:AD15				X				
43123C3:AD17				X				
43123C3:AD18				X				
43123C3:AE06				X				
43123C3:AE07					X			
43123C3:AF07					X			
43123C3:W27					X			
43123C3:W28					X			
43123C3:X26					X			
43123C3:X27			X					
43123C3:Y24					X			
43123C3:Y25					X			
43123C3:Y26			X					
43123C3:Z23							X	
43123C3:Z24					X			
43123D2:BM48					X			
43123D2:N68					X			
43123D3:AB71					X			
43123D3:AC71					X			
43123D3:AD70					X			
43123D3:AS67					X			
43123D3:AV65								X
43123D3:AY64								X
43123D3:BJ65						X		
43123D3:H63					X			
43123E3:BE40					X			
43123E3:BE41					X			
43123E3:BF39					X			
43123F3:AW72					X			

$\chi^2 = 48.49$; $p < 0.001$

Appendix 3. Summary of Threats and Recommended Recovery Actions

LISTING FACTOR	THREAT	RECOVERY CRITERIA	RECOVERY ACTION NUMBERS
A	Conversion of wet meadow habitat to agricultural use	1, 2, 3, 5	1.1, 1.2
A	Fire exclusion and vegetational succession	1, 2, 3, 5	1.1, 1.2, 4
A	Filling and draining of wetlands for residential and commercial development	1, 2, 3, 5	1.1, 1.2
B	Plant collectors	1, 2, 3	1.1, 1.2, 4
C	Excessive livestock grazing	1, 2, 3, 5	1.1, 1.2, 4
D	Inadequate enforcement of State and Federal wetland legislation	1, 2, 3	4
E	Competitive exclusion by native and nonnative wet meadow vegetation	1, 2, 5	1.1, 1.2
E	Accidental herbicide spraying or chemical spills near railroad or highway rights of way	3	1.1, 1.2, 4
E	Habitat fragmentation	1, 2, 4, 5, 6	1.1, 1.2, 2.1, 2.2, 3.1, 3.2

Appendix 4. Summary of Comments on the Draft Recovery Plan for the Rough Popcornflower

In January, 2003, we released the Draft Recovery Plan for the Rough Popcornflower (Draft Plan) (U.S. Fish and Wildlife Service 2002) subject to 60-day public comment period. The public comment period ended on March 31, 2003. During this comment period, comments from two State agencies and four peer reviewers were received. The four peer reviewers were: Tom Kaye, Darren Borgias, James Kagan, and Russell Holmes.

A summary is provided of the significant comments received. All letters of comment on the Draft Plan are kept on file in the Roseburg Field Office, 2900 NW Steward Parkway, Roseburg, Oregon 97470.

The following is a breakdown of the number of letters received from various affiliations:

Federal agencies - 1
State agencies - 3
local governments - 0
business/industry - 0
environmental/conservation organizations - 1
academia/professional - 1
individual citizens - 0

This section summarizes the content of significant comments on the Draft Plan. A total of six sets of comments were received. Some specific comments reoccurred in letters or e-mail messages. A few reviewers provided new information or suggestions for clarity. This information was incorporated into the final version of the recovery plan. Some letters requested an explanation of various points made in the Draft Plan or their scientific basis. In these cases, the recovery plan was revised to include an expansion or clarification of the particular section. Some reviewers gave their support for the recovery plan. Information and comments not incorporated into the final version of the Draft Plan were considered, noted, and are on file with the entire package of agency and public comments; these may become useful in the future. Significant comments that were not incorporated or that require clarification in addition to their incorporation are addressed below.

Summary of Comments and Our Responses

Four peer reviewers and two State agencies supplied comments to the Draft Rough Popcornflower Recovery Plan (U.S. Fish and Wildlife Service 2002). The comments are categorized by habitat and ecology, recovery objectives and strategy, downlisting recovery criteria, monitoring, and implementation schedule.

Habitat and Ecology

Comment: There is no evidence that gene flow among interbreeding populations has become further restricted with respect to popcornflower.

Response: Surveys for rough popcornflower conducted by Kaye *et al.* (1998) and Amsberry and Meinke (1999) have indicated a loss of habitat to agriculture and development. By comparing the historic range of rough popcornflower, along with its preferred habitat soil types to present available habitat and current range, it is likely that historic habitat has been further restricted. The likelihood of restricted gene flow is based on pollinator interactions. The distance a pollinator will typically travel could serve as an indication that gene flow has been further restricted in the recent past. See Recovery Criterion number 4 for pollinator distances and refer to the description of Calapooya Creek Recovery Unit.

Recovery Objectives and Strategy

Comment: The note following the recovery objective seems to somewhat negate the possibility of a delisting. Currently, naturally vigorous populations within the range of rough popcornflower are not known and may not exist. This statement seems to throw into question the recovery objectives. Please clarify or put this statement into some context that supports the implementation of the recovery objectives.

Response: There are few naturally viable populations that are both secured and protected. There is an ongoing effort to secure, protect and enhance existing populations. Delisting criteria can be developed once the more immediate threats have been reduced, and the plant populations that meet the six recovery criteria are more stable. The statement was reworded in the

document to better clarify the justification to postpone formulation of delisting criteria.

Comment: Gene flow has probably always been limited between sites. Why has such a tight distance of 1 kilometer between populations been selected for a recovery objective? Available habitat/ownership may interfere with meeting this objective.

Response: One kilometer is a distance that is used to delineate reserve boundaries. A patch within 1 kilometer from another patch should have active pollination present by a variety of pollinators, however, once the distance exceeds 1 kilometer, on average, there is a lesser degree of active pollination between two patches. Rare plants can suffer from a reduction in the number of available generalist pollinators as these pollinators prefer more common plants (Amsberry 2001).

Comment: In the case of recovery unit designation, is the definition of "species" equal to that of the "recovery unit"? If this is the case, this needs to be clearly defined and linked to the listing package in the Federal Register in some way. The recovery strategy seems to indicate the recovery unit will be the level used to analyze effects to the species under section 7 of the Endangered Species Act. This is similar to the National Marine Fisheries Service approach with Evolutionary Significant Units, however, the Evolutionary Significant Units were clearly identified in the Federal Register and had public comment.

Response: Jeopardy analyses may be based on an assessment of impacts to recovery units when those units are documented as necessary to both the survival and recovery of the species in a final recovery plan, for which a notice of availability has been published in the Federal Register. When an action significantly impairs or limits the capability of a recovery unit from providing the survival and recovery function to a species, that action may result in jeopardy to the species. In the case of the rough popcornflower, the survival of the plant population in the recovery unit may be deemed crucial to the survival of the species (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

Comment: Would activities in un-occupied suitable habitat within a recovery unit without direct impacts to plants be subjected to Endangered Species Act regulations? If so, how?

Response: No, unless there was a clear line of reasoning that the proposed Federal activity could be associated with potential impacts to a plant species. If a Federal action was determined to "may affect" the species, the action agency would have to complete section 7 consultation pursuant to the Endangered Species Act.

Downlisting Criteria

Comment: Additional rationale needs to be provided regarding the 5,000 minimum population size estimate for a reserve population. Provide some discussion on the population effective size and ways the rough popcornflower breeding system and ecology might affect effective size. Five thousand rooted nodes is not the same as an effective population size. The actual effective size could be lower than 5,000 plants. Because plants root at nodes easily, they do not have to maintain a large effective size population. Perhaps a lower minimum number for Criterion number 1 is more appropriate. The recovery plan needs a more meaningful justification for a minimum population size of 5,000 plants.

Response: Based on work by Culotta (1995), Lande (1995), and Lynch *et al.* (1995), we expanded the effective population size of 500 plants by a factor of 10 to arrive at 5,000 plants. This number represents the minimum viable population size capable of resisting inbreeding depression and deleterious alleles, which has been documented in plant species with similar life cycles and reproductive strategies (*i.e.*, biennial, self crossing). The Final Recovery Plan was revised to clarify our rationale.

Comment: What is the rationale for requiring three viable population reserves established in each recovery unit as a downlisting criterion for rough popcornflower? The document does not lead the reader to begin thinking in terms of the narrowing (or broadening) focus on selecting "nine" reserves. It seems that the importance of the selected nine could perhaps be introduced earlier on the preceding page under Recovery Strategy.

Response: The basis for recovery units and reserves is to ensure the genetic and biological diversity of the species. Requiring a minimum of three reserves per recovery unit should provide a measure of protection for genetic diversity and safeguard the recovery unit from random, naturally occurring events. The three reserves would reflect the observable geographic grouping of known and historic rough popcornflower locations occurring on a full range of suitable habitat microsites. The Final Recovery Plan was revised to clarify our rationale.

Comment: There should be more justification for Recovery Criterion number 5 (An average of 5 years of demographic data to indicate that at populations in at least seven of the nine reserves within the recovery units have average population numbers that are stable or increasing, without decreasing trends lasting more than 2 years), number 6 (75 percent or more of the plants are reproductive each year, with evidence of seed maturation and dispersal in all populations), and number 7 (seed germination and seedling recruitment are occurring in all populations). Criterion number 7 seems redundant.

Response: A justification and discussion for 5 years of population monitoring, 30 percent seed maturation, and 75 percent reproduction has been added to the recovery strategy as well as rationale for the requirement of no more than 2 years of a decreasing population trend. Seed germination and seedling recruitment (Criterion number 7) was combined with Recovery Criterion number 6. Dispersal is more clearly explained in the life history section.

Comment: It may be better to invest in fewer, larger reserves comprised of much larger populations over much larger areas of existing or restored habitat than investing in many, small, isolated populations.

Response: The main intent of the recovery plan is to conserve the species through establishment of a network of protected populations in natural habitat distributed throughout its native range. The intent of Recovery Criterion number 4 is to create a network of linked patches so that pollinator movement is unimpeded throughout the population. Much larger reserves would not be required to support pollinator movement.

Comment: The 9,000 square meters (1,000 square meters per reserve) is considerably less than the 158,000 square meters documented as already occupied in Appendix 1.

Response: Although there may be more than 9,000 square meters occupied by rough popcornflower in the three recovery units, these are not necessarily protected and managed at this time. In addition, some of the reserves may not meet the five other Recovery Criteria.

Comment: Some means of sampling to obtain a quantitative estimate of population should be provided for populations that have considerably more than 1,000 plants.

Response: A procedure using subsampling to characterize the population size was added to Recovery Criterion number 2 of the recovery plan. This sampling procedure should facilitate sampling in most populations. Additional effective sampling methods could be utilized if available.

Comment: The subcriterion including rough popcornflower densities in excess of 100 plants/square meter at each site seems unrealistic. In sampling conducted in 2002, the highest average density in any of the monitored patches across the entire population was only 12 plants/square meter. Certainly there are more dense patches, but these hardly seem worth the effort to document.

Response: In the majority of natural plots sampled throughout the range of rough popcornflower the average density was 100 plants/square meter. In some populations, plants are stressed by canopy cover, spacial competition with encroaching plants, or poor hydrology. Populations facing these conditions may persist for a number of years with a less vigorous growth habit and in smaller numbers than plants in open wet meadows (K. Amsberry, pers. comm. 2003a). The language was revised in the recovery plan in several areas to provide clarity.

Monitoring

Comment: Monitoring should quantify and specify reproduction and recruitment for populations and include mapped extent and estimate of occupied area.

Response: In Action number 1.1.4.5, monitoring will include an assessment of reproduction, recruitment, mapped extent, and estimate of occupied area. The recovery criterion includes a minimal percentage of reproduction. The recovery plan has been revised to clarify the appropriate monitoring necessary.

Implementation

Comment: Mapping and documentation actions in the recovery plan are overly expensive. The implementation plan is too costly for realistic expenses and actions for seed collection seem exorbitant and redundant.

Response: Cost estimates have been based on similar work already conducted as part of ongoing research for the species. Seed collection costs were verified and used to revise the cost estimates in the recovery plan (E. Guerrant, R. Meinke, pers. comm. 2003).

Appendix 5. Monitoring Plan and Sample Monitoring Data Form

The rough popcornflower recovery plan includes periodic monitoring for extant population presence, area occupied by rough popcornflower, number of individuals, percent reproduction, and recruitment as identified in Action 1.1.5.5. Monitoring should be completed at least annually, using the following Monitoring Form. Monitoring should include measurement of population size and viability. Monitoring should be conducted at intervals to allow detection of population decline or loss of viability. If recovery actions are found to not be effective, then alternative measures should be developed.

Explanation of site/reserve monitoring criteria

Area: Total amount of square meters currently occupied by rough popcornflower population at the site.

occupied meters: Number of meters that meet the downlisting requirement of 100 rooted stems, nodes and rosettes per square meter.

Percent germination: Percent germination for each monitoring plant population.

Percent reproductive: Percent of plants that are flowering.

Percent recruitment: The percent of new recruitment for each population.

Threats of invasive plants: Are threats from invasive plants present at the site?

Herbivory: Is herbivory occurring at the site?

Dispersal: Is dispersement of plants occurring at the site?

Land Ownership: City, State, Federal, private, conservation organization, or other ownership.

Protection and/or Management Status: Current protection status of the site. For example, is the site unprotected, protected, managed with conservation easement, a mitigation site, a land trust conservation site, or has other type of management.

Rough Popcornflower Monitoring Form

Site	Year	Area	# occupied meters	Percent Germina-tion	Percent Reproduc-tive	Percent Recrui t-ment	Threats of Invasive Plants	Herbivory	Dispersal	Land Owner-ship	Protected or mgmt Status
Sutherlin Creek Recovery Unit											
Hawthorne 2 EO*007											
Sutherlin 1 EO*001											
Popcorn 1 EO*009											
Glide Lumber EO*012											
Wilbur North EO*012											
Deady Crossing South EO*005											
Deady Crossing North EO*005											
Calapooya Creek Recovery Unit											
Stearn's Lane EO*014											
Yoncalla Creek Recovery Unit											
Yoncalla 2 EO*004											

Note: Rows are intentionally left blank to accommodate additional population information.