CONSERVATION STRATEGY

Calamagrostis breweri Thurb.

Mt. Hood and Willamette National Forests

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EXECUTIVE SUMMARY

Species and Taxonomic Group

A recent paper has proposed a change in the taxonomy of the rare sub-alpine meadow grass *Calamagrostis breweri.* The study recognizes the southern populations in the Sierra Nevada Mountains as distinct from the northern populations (Wilson and Gray, 2002). This action recognizes two species, a northern entity (from Carson Pass, CA through Oregon) which retains the name *C. breweri*, and a new southern species (from Tioga Pass, CA and south) called *Calamagrostis muiriana*.

Management Status

The taxonomic redefinition of this species did not affect state ranking for *C. breweri* (S2, imperiled in Oregon), but it changed the Oregon Natural Heritage global rarity ranking from G5 (secure and locally abundant) to G3 (vulnerable, at moderate risk of extinction In the state of Oregon).

Range and Habitat

Calamagrostis breweri is a disjunct endemic grass species whose known distribution on National Forest lands within Oregon is limited to Mt. Hood and Mt. Jefferson in the northern Cascade Mountains of Oregon. This grass is restricted to subalpine habitats in a narrow elevation range in Oregon. Most populations in Oregon occur between 1524 and 1829 meters (5000-6000 feet). *C. breweri* is usually found in moist meadows with limited vegetative competition from species such as *Phyllodoce* and *Cassiope*.

Threats

Threats to the survival of *C. breweri* are categorized as natural and human-related. Natural threats that have been documented include herbivory and seed predation on Mt. Hood and may have been caused by insects, rodents and/or ungulates. The greatest natural threat to *C. breweri, outside* the large-scale stochastic events, may be global climate change. The low level of genetic diversity present in remaining populations may be insufficient to enable adaptation to rapidly changing habitats and competition from encroaching vegetation.

Both Mt. Hood and Mt. Jefferson experience high levels of recreational activity in and adjacent to *C. breweri* populations. Recreational activities (hiking, horseback riding, camping) cause trampling, compaction and erosion in populations that are accessible via the Timberline Trail from the south, east, north and northwest sides of Mt. Hood. There are many off-trail/user created trails through moist meadows where *C. breweri* is known to grow in both Mt. Hood and Jefferson Park. Areas immediately adjacent to Jefferson Park lakes are most impacted by recreation visitors; large areas of vegetation have been damaged and modified from camping related activities.

Additional human-related threats on Mt. Hood National Forest occur as a result of the building and maintenance of Mt. Hood Meadows Ski Area. Historic impacts have included construction of ski lift structures, buildings, and roads. Current threats include development of slopes for ski runs; operation of annual snow grooming machinery over habitat to optimize skiing conditions or to accommodate early and late season skiing, and salting ski runs over habitat areas to optimize skiing conditions (both activities may affect phenology during short growing seasons); operating brush mowing machinery through *C. breweri* habitat; some annual summer maintenance routines that involve off-road use of all-terrain vehicles; collection of native plant "shovel plugs" from *C. breweri* habitats in the vicinity of restoration projects (unapproved collections may interfere with data collection from monitoring plots). Populations located in moist meadows down slope of ski runs may have also been indirectly affected by changes in hydrology caused by the removal of trees and shrubs, and in some places by the diversion of streams.

Conservation

Conservation of the *C. breweri* comes through management recommendations for high priority populations selected for maintenance of the species. These include:

- Management and monitoring of all designated high priority sites.
- Maintenance or reduction of recreational disturbance pressure on high priority sites using a variety of strategies.
- Development and implementation plans for restoration of habitat and *Calamagrostis breweri* reintroduction.
- Preparation of educational materials for wilderness visitors
- Removal of non-natives from *Calamagrostis* habitat

In addition, there are specific management guidelines only pertinent to the Mt. Hood National Forest populations within the Mt. Hood Meadows Ski Area (Mt. Hood Meadows Ski Area Master Plan Record of Decision, 1997).

Inventory, Monitoring and Research

Research needs for *C. breweri* fall into five categories: 1) Role of soil disturbance in ecology of the species; 2) Role that snow management plays in the survivorship of *Calamagrostis*; 3) The role soil types play in the disjunct distribution of the species; 4) Common garden studies to further investigate genetic differences between Hood and Jefferson populations; 5) Analysis and inventory of potential distribution of *C. breweri* between Mt Jefferson and Mt. Shasta in California.

The monitoring protocol is composed of defensibility and population level monitoring. The objectives are: 1) Develop baseline information on high priority populations across the range to be used to assess if/when populations require active management; 2) Determine which current threats are adversely affecting populations; 3) Attempt to quantify adverse effects.

Adaptive Management

The adaptive management section discusses data analysis and triggers for active management and triggers for reassessment of high and low priority populations.

SIGNATURE PAGE

/s/ Margaret Mitchell
Margaret Mitchell
Forest Supervisor
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June 6, 2011
Date

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RANGE AND DISTRIBUTION

Based on the most recent work (Wilson and Gray, 2002) *Calamagrostis breweri* has an unusual and distinct distribution, found only in (1) the Cascade Mountains of northern Oregon, (2) the Salmon, Klamath and Trinity Mountains of northern California, and (3) the northern Sierra Nevada Mountains of California (Figure 1). In Oregon, it is only known from two areas, the first on the north side of Mount Jefferson, on the Willamette National Forest (Figure 2) and the second on both sides of Mt. Hood on the Mt. Hood National Forest (Figure 3).

Calamagrostis breweri has not been found south of Mount Jefferson in the Oregon Cascades. No inventories have been conducted in high probability habitats between the disjunct northern Oregon and northern California populations, nor has there been an attempt at a comprehensive survey in California to determine the exact distributions of *C. breweri* and *C. muriana*. There are no known extirpated populations of this species in Oregon or California.

PLANT DESCRIPTION AND TAXONOMY

Calamagrostis breweri [Poaceae] is a delicate, caespitose (tufted or bunchgrass) perennial, found on stream banks, lake margins and moist alpine or subalpine meadows and tree islands.

A recent paper has proposed a change in the taxonomy of this grass, recognizing the southern populations of the Sierra Nevada Mountains as distinct from the northern populations (Wilson and Gray, 2002). This action recognizes two species, a northern entity (from Carson Pass, CA through Oregon) which retains the name *C. breweri*, and a new southern species (from Tioga Pass, CA and south) called *Calamagrostis muiriana*. The paper is accepted as the basis for the taxonomy, description, and distribution information in this Conservation Strategy. The distinctiveness of the two species proposed by Wilson and Gray (2002) has been recently demonstrated using an independent molecular genetic approach (Cronn et al., 2003). The plant description below is taken directly from Wilson and Gray (2002).

Plant Description and Keys

Plants with intravaginal (occasionally extravaginal) shoots. Young plants densely tufted. Old plants spreading outward while dying in the middle and thus forming rings about 1.5 dm in diameter. Foliage glaucous, 10 - 20 cm long. Leaf sheaths open, scabrous. Ligules 1.7 - 4.1 mm long, entire to erose. Leaf blades flat but readily rolling when dry, well-developed leaves (2-) 10 - 15 cm long, 0.4 - 0.6 mm wide when rolled, the innovation leaves 0.9 - 1.1 mm wide when flat, (earliest leaves of innovations only slightly reduced), the culm leaves 1.3 - 1.7 mm wide when flat, leaf blades abaxially scabrous, adaxially pubescent; leaf blades of innovations with 7 - 9 veins and 9 - 11 abaxial sclerenchyma bundles; leaf blades of culms often with 11 or more veins. Leaf tip prow-shaped. Flowering culms taller than the foliage and 29 - 54 cm tall. Inflorescence a spreading panicle, few-flowered, 5.7 - 8.4 cm long, and 0.7 to 5.2 cm wide, pale to dark purple. Spikelets one-flowered, with a sterile rachilla about half as long as the floret and covered with long white hairs. Glumes subequal in length, the lower 3.1 - 4.9 mm long; the upper 3.3 - 4.5 mm long. Glumes thin-textured, pale to dark purple or

sometimes greenish, often with hyaline margins distally (occasionally straw-colored), acute to apiculate, minutely awned, or attenuate, rounded on the back or keeled distally, glabrous (occasionally scabrous), sometimes with hairs on the keel. Lemma 2.6 - 4.0 mm long, thin-textured, hyaline or dark purple, glabrous or scabrous, usually with purple on veins distally, the veins extending as four short teeth. Callus beard hairs white, 0.3 - 1.2 mm long. Lemma awn purple, arising from below the middle of the lemma, 3.4 - 5.5 mm long, geniculate, extending beyond the glumes. Palea hyaline, pigmented along veins distally, about as long as the lemma. Mature anthers 1.3 - 2.6 mm long, purple. 2n = 42.

Key to alpine reedgrasses of western North America:

1. Leaves extremely thin and involute, 0.25 - 0.4 mm wide as rolled, with 3 (-4) veins, the tip straight-sided; panicle length 1.9 - 5.7 cm; callus beard hair length 0.3 - 0.6 mm; range south of Sonora Pass (Yosemite area and south)

C. muiriana Wilson and Gray

1. Leaves narrow, flat in life but readily rolling when wilted, 0.4 - 0.6 mm wide as rolled, with 7 or more veins, the tip prow-shaped; panicle length 5.7 - 8.5 cm; callus beard hair length 0.3 - 1.2 mm; range north of the Sonora Pass (Carson Pass area north to Mt. Hood Oregon)

C. breweri Thurber *s. str.*

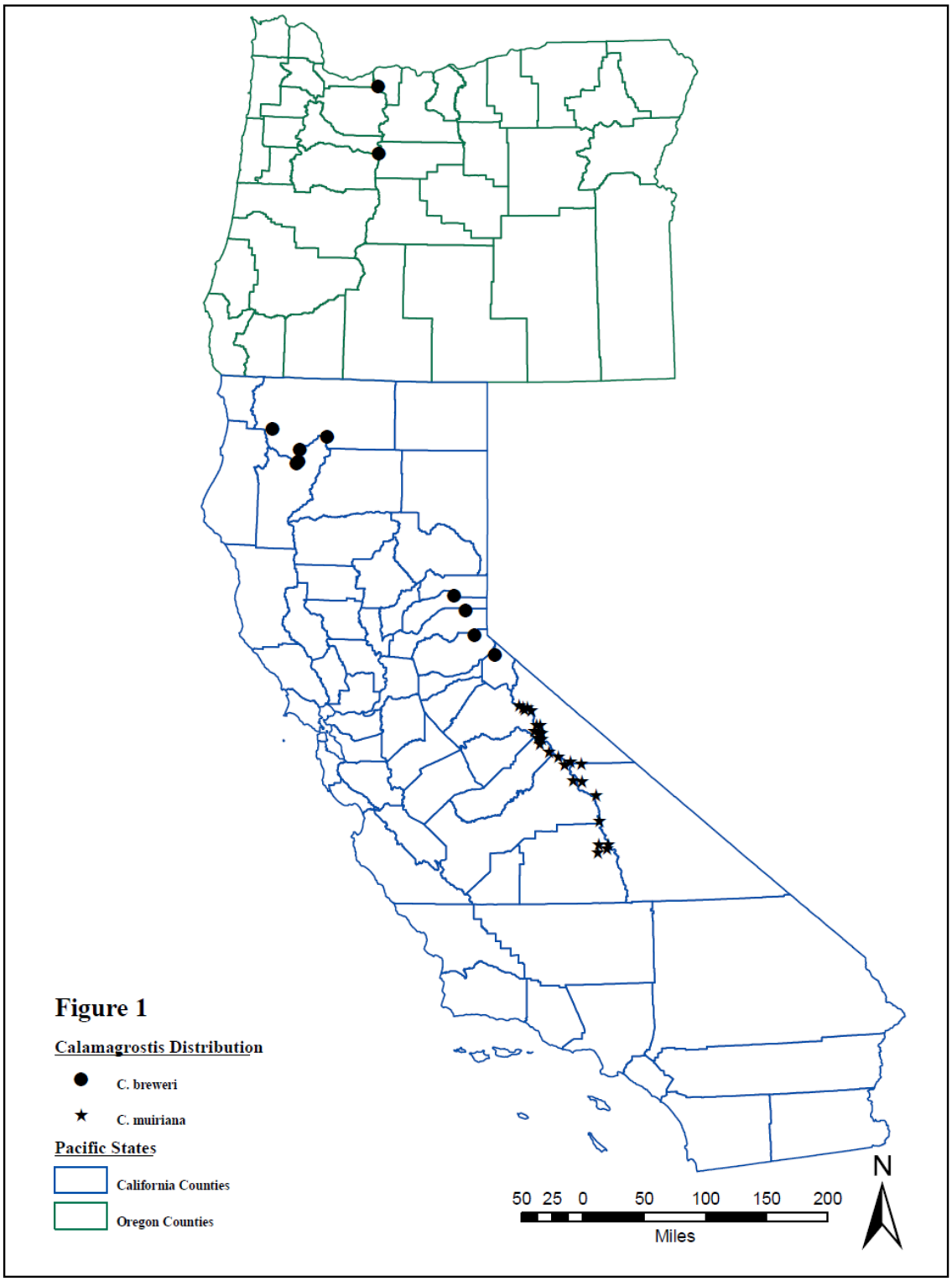

Figure 1: Distribution of *Calamagrostis breweri* Thurber (s.s.) and *Calamagrostis muriana* Wilson and Gray. From Wilson and Gray (2002).

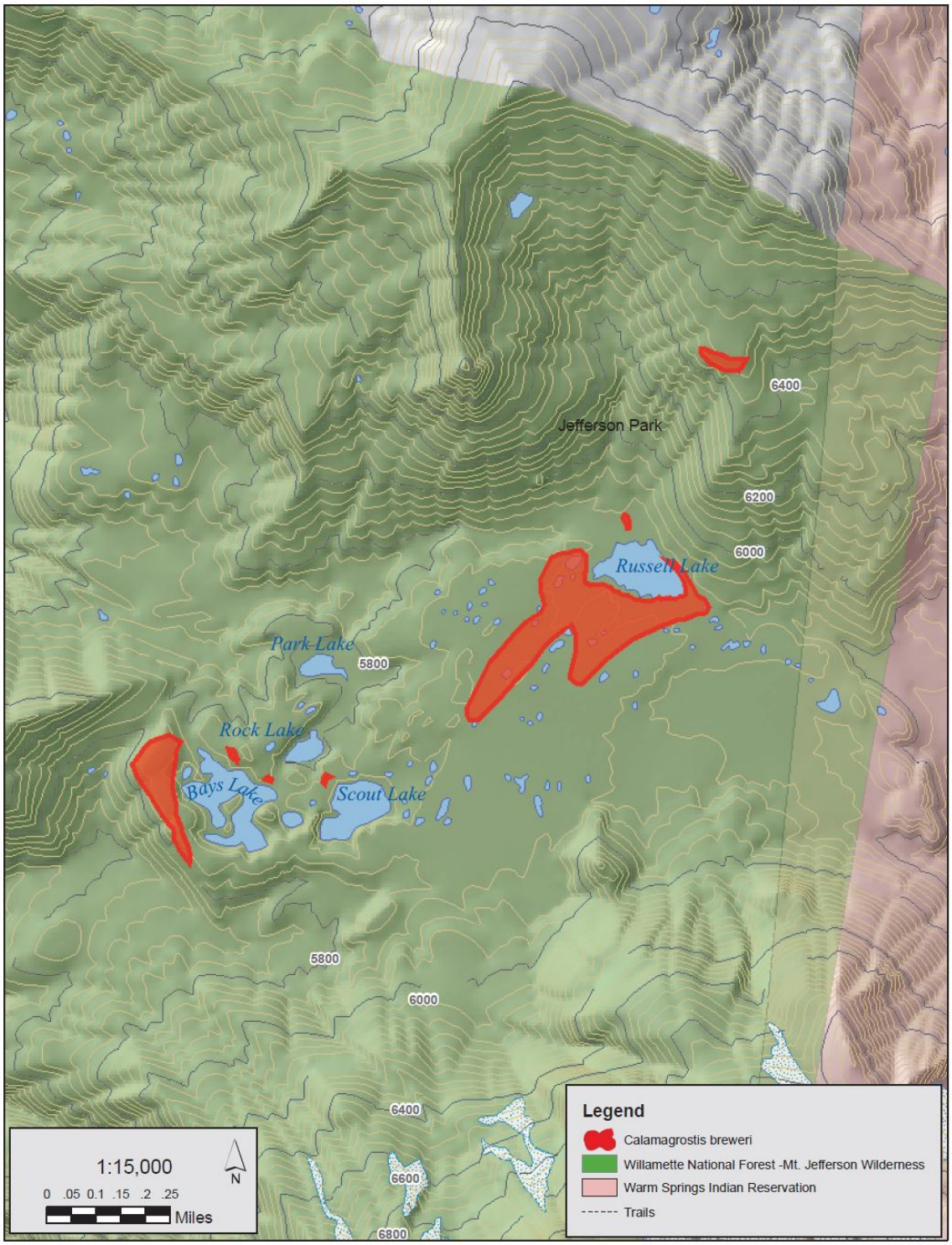

Figure 2. *Calamagrostis breweri* at Jefferson Park, Mt. Jefferson Wilderness, Willamette National Forest

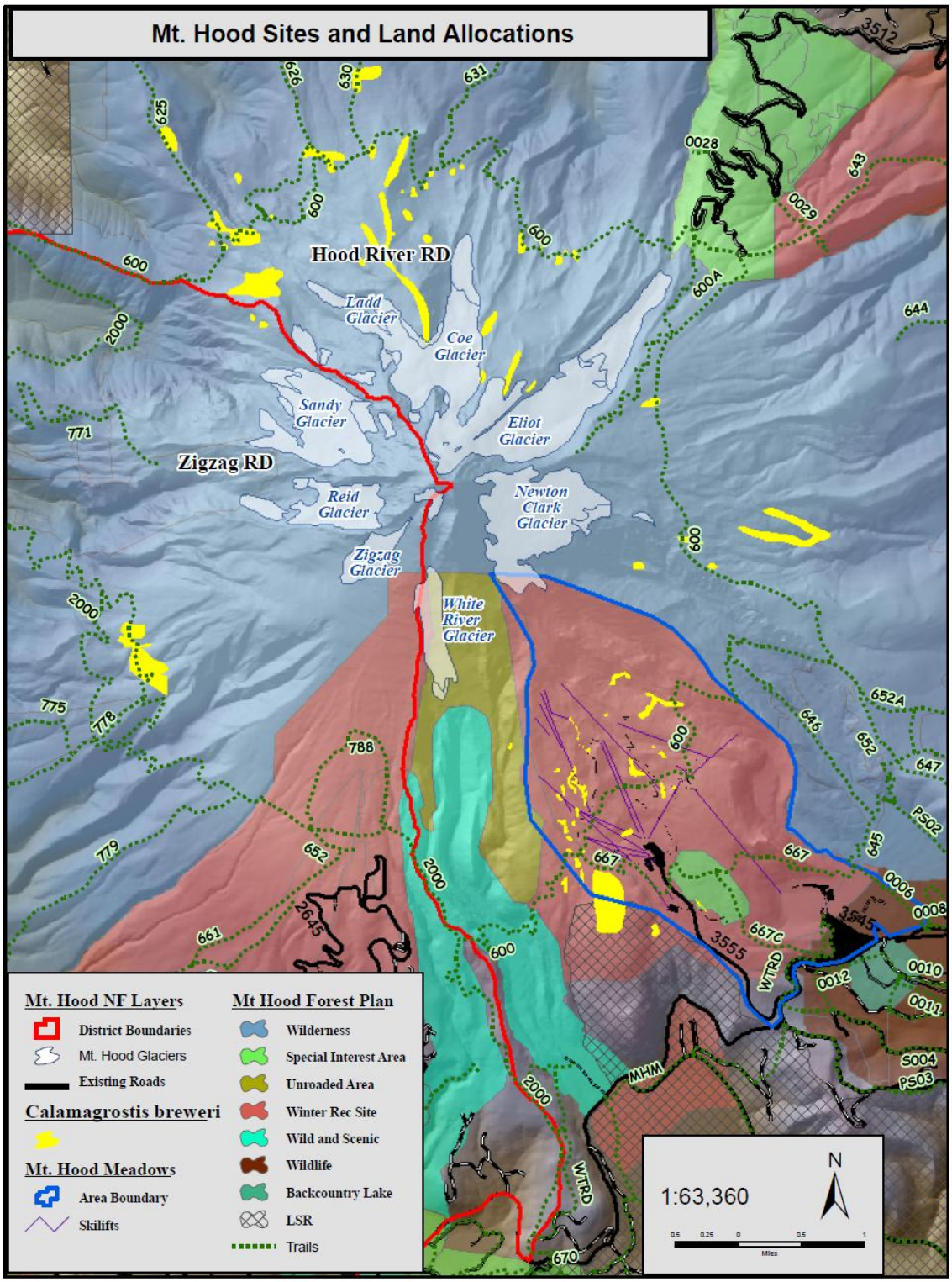

Figure 3. ***Calamagrostis breweri*** **on Mt Hood, Mt. Hood National Forest**

GLOBAL AND STATE RARITY

The taxonomic redefinition of this species did not affect state ranking for *C. breweri* (it is S2), but it had changed the Oregon Natural Heritage global rarity ranking from G5, secure and locally abundant, to a G3, vulnerable, at moderate risk of extinction. *C. breweri* is not tracked by the California Natural Heritage Program.

HABITAT DESCRIPTION IN OREGON

Calamagrostis breweri is restricted to subalpine habitats in a narrow elevation range in Oregon. On Mt. Hood, known sites have been documented at elevations that range from 1494 meters (4900 feet) near Stringer Meadows to 2091 meters (6860 feet) near Gnarl Ridge. Most populations in Oregon occur between 1524 and 1829 meters (5000-6000 feet). All of the sites are seasonally moist, but specific habitats vary. Site reports indicate that *C. breweri* is usually found in microsites with limited vegetative competition. Almost all populations are reported from open meadows, but some sites contain tree species, most frequently *Tsuga mertensiana*.

A few of the Oregon occurrences list dominant associated species. The most important of these associates are included in Table 2, with their range of cover values when reported. Other species associated with *C. breweri* may be found in Appendix B.

Table 1. Species associated with *C. breweri* and cover value ranges

Plant Type and Species	Cover Value
Shrubs	
Phyllodoce empetriformis	1-70%
Graminoids	
Agrostis thurberiana	10%
Agrostis variabilis	3-20%
Carex illota	20%
Carex nigricans	10-90%
Carex scopulorum	15%
Carex spectabilis	2-10%
Forbs	
Anemone occidentalis	15%
Aster alpigenus ssp. alpigenus	1-10%
Erigeron peregrinus ssp. callianthemus	1-70%
Hieracium albiflorum	10%
Ligusticum grayi	4-40%
Luetkea pectinata	1-50%
Lupinus latifolius var. *latifolius*	1-10%
Polygonum bistortoides	10%
Potentilla flabellifolia	1-30%

The most common associate is *Carex nigricans*, found at 23 of the 26 plots (88.5%) with species lists sampled in Oregon (USFS files). *Carex spectabilis* is found at the other three plots, indicating the presence of an alpine wetland sedge component at all sites in

Oregon. *Luetkea pectinata* is the species with the next highest constancy, found in about 62% of the sampled occurrences.

The only published vegetation classification data from the immediate range of *C. breweri* is from a study of ski slope vegetation from Mount Hood (Titus and Tsuyuzaki 1999). In this paper, 17 communities were described, six of which were sedge meadow, montane meadow, or alpine forbland communities. None were characterized by *Carex nigricans* or *Calamagrostis breweri*, nor was either of these species included in any of their species lists. However, all six have some components of the proper habitat for *Calamagrostis breweri*. These types are listed below:

1. *Carex halliana – Carex multicostata* sedge meadow
2. *Carex spectabilis – Carex paysonis* sedge meadow
3. *Deschampsia atropurpurea* montane meadow
4. *Carex paysonis – Eriogonum umbellatum* alpine forbland
5. *Antennaria umbrinella – Carex spectabilis – Lupinus lepidus – Elymus elymoides* alpine forbland
6. *Polygonum newberryi – Luetka pectinata – Aster alpigenus* alpine forbland

The soils found at the sites are comprised of alluvial deposited silt, loams and glacial till. In benches and some lake margins, soils also include clay loams, generally silty or sandy clay loams. Records from six sites in Mt. Hood indicate that four of the sites are primarily silt loam, one site is sandy loam, and one site is sandy clay loam. In general soils on and around Mount Hood and Mount Jefferson are derived from ash falls, mudflows, and pumice, and are nutrient poor.

As is the case with most alpine areas in the Pacific Northwest, these sites are characterized by having cold, wet winters and springs, and a summer drought. Annual precipitation varies, but has a mean of about 255 cm (National Resources Conservation Service 2009). Almost all of the precipitation falls as snow in the winter and spring, and the snowpack in these areas often exceeds 4 meters in the habitat of *C. breweri*.

Mycorrhizal Relationships

Cazares (1997) sampled soil within the Mount Hood Meadows Ski Permit Area to determine whether there is an association between *Calamagrostis breweri* and mycorrhizal fungi. Mycorrhizal associations are mutualistic between a fungus and a plant and are known to be involved directly in the water and nutrient uptake, especially when these resources are available in limited quantities. Mycorrhizae can be important to the long-term success of a species by determining seedling survival. Enhancing the mycorrhizal condition of sensitive plants may be an important management tool to help ameliorate damages caused by humans (Cazares, 1997). An unpublished report (Cazares, 1997) on the mycorrhizal associates of *C. breweri* concluded that the species does indeed have vesiculo-arbuscular mycorrhiza, and that in undisturbed populations, these appear to be abundant as both spores and hyphae.

REPRODUCTIVE BIOLOGY

In recent studies *Calamagrostis breweri* was grown in greenhouse conditions, where it demonstrated the capacity to maintain itself sexually via seed production and asexually via tillering and rhizome formation (Figures 4, 5). Wilson and Gray (2002) report growing *C. breweri* and *C. muiriana* under greenhouse conditions to determine if differences in growth form were due to phenotypic plasticity or genetic divergence. These authors reported that both species could be grown from tillers. In their unpublished study notes, Barbara Wilson stated that "greenhouse planted *C. breweri* from Mt. Jefferson had considerable mortality, probably a result of being collected virtually rootless. Otherwise it [*C. breweri*] grew fine. It did not flower in the greenhouse. I assume it needed exposure to cold. We never collected nor germinated any seeds."

In follow-up studies, Richard Cronn (USDA Forest Service, 2003) planted seeds and rooted tillers of Oregon *C. breweri* in raised beds at the Forest Sciences Laboratory in Corvallis, OR in March 2002 (Figure 4) for the purpose of having easy access to plant material for genetic studies. Seedlings and vegetative starts were easily established, and the plants grew vigorously throughout the 2002 season. In the first season, plants expanded by extravaginal tillering (Figure 5c), but did not show evidence of flowering or rhizome formation. During the winter of 2002-2003, these plants suffered high mortality (approx. 60%) at the Corvallis site due to over watering and fungal pathogens.

Figure 4. Common garden planting of *Calamagrostis breweri* in raised beds at the Corvallis Forestry Sciences Laboratory. Plants in this photo had grown two seasons.

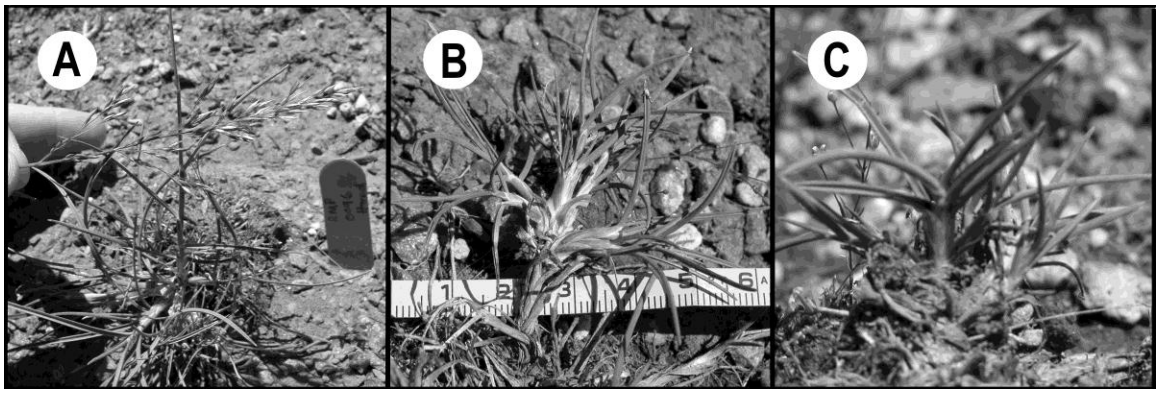

Figure 5. Modes of sexual and clonal propagation demonstrated by *Calamagrostis breweri* grown in a common garden. A) Flower and seed set. B) Rhizome formation in *C. breweri* (in cm) C) Extravaginal tillers. Photos by Dr. Richard Cronn, Corvallis Forest Service Lab.

In 2003, surviving plants increased their clonal diameter due to a combination of modest rhizome formation (Figure 5b) and extravaginal tillering (Figure 5c). In addition, most of the surviving plants flowered between April and June. Prior to anthesis, these plants were bagged with nylon bags to prevent insect pollination, and flowers were shaken to promote self-pollination. Seed was produced on *all* inflorescences, and visual inspection shows the majority of caryopses to be filled

Seed viability and germinability of wild-collected *C. breweri* has been evaluated for both the Mt. Hood and Mt. Jefferson populations. Seed collections by Cronn and colleagues in October and November of 2001 and 2002 showed germination rates ranging from a low of 2% to a high of 98% (Cronn, 2004) and the majority of lots showed germination rates over 80%. Since seed collection was not a major goal for this study (it was primarily collected for herbarium voucher specimens), low germination rates were likely due to individual-plant differences in the timing of flowering and ripening. Stratification appears unnecessary in *C. breweri*, as homogenized seed lots showed only a modest improvement in overall germination after a 28-day stratification at 4°C (98% for stratified seed, 90% for unstratified). In uncontrolled comparisons between greenhouse-sown and bed-sown *C. breweri*, there appeared to be no detectable difference in germination percentages or growth rate. The length of *ex situ* seed viability is unknown in this species, as are the optimum storage conditions. Despite this lack of knowledge, seed storage for *C. breweri* is unlikely to present challenges, as seedlings have been successfully germinated from seven year-old dried specimens that were mounted on herbarium sheets.

Even though individual plants may expand slowly via tillering and rhizome formation (Figure 5), evidence from greenhouse studies of *C. breweri* seems to indicate that the plant is unlikely to exhibit clonal growth on a scale similar to that shown by more noteworthy members of the genus (e.g., *C. canadensis, C. rubescens*). In contrast, seed derived from self fertilization (or asexual mechanisms like apomixis or agamospermy) is abundant, and it appears that seeds may represent the most important strategy for maintaining populations and dispersing to new locations.

While we lack information on the relative importance of sexual versus clonal growth in maintaining *C. breweri*, a recent study by MacDonald and Lieffers (1991) reported on the potential influence that landscape disturbance exerted on diversity and the frequency of

outcrossing in *C. canadensis*. Results show that this highly rhizomatous species establishes new populations primarily via sexual reproduction (via outcrossing or self-pollination) as opposed to asexual means. Since the highly rhizomatous species *C. canadensis* relies heavily upon sexual reproduction and seed dispersal for population maintenance and dispersal, we *assume* that *C. breweri* shows an even greater reliance on seed-based strategies for long term population viability.

POPULATION BIOLOGY

To date, the population demographic structure of *C. breweri* has not been studied in detail, in part due to the challenge of identifying *C. breweri* seedlings in the field (not yet reported). Oregon populations are quite variable, with the majority being quite small (with population areas reported in square feet, and individual plants easily counted). Only three are described as "large". Of these large populations, the Dollar Lake area was recently characterized for reproductive effort. In 1995, Stein and Holmberg reported counting 5000 culms of which 50% were vegetative and 50% were flowering or fruiting. The second large population is from a number of patches in and around Mount Hood Meadows Ski Area, near Heather Canyon and Clark Creek. No population numbers are given here, but the numbers are indicated to be in the tens of thousands. The Jefferson Park population numbers have been roughly tallied at over 1000 "clumps", with each clump comprising from 1 to 25 culms. Aside from these occurrences, all others are smaller and more local, with fewer than 1000 plants in areas less than 100 acres, and most in areas only one to two acres. Some records of smaller populations report that plants tend to be found in areas where there is less competition with shrubs, such as *Phyllodoce empetriformis*.

GENETICS

A great deal of genetic work has been conducted on *C. breweri s.l.*, including a cytogenetic survey by Nygren (1954), an allozyme survey (Wilson et al., 1995; Wilson and Gray, 2002), and most recently a DNA-based study of nuclear and maternally-inherited chloroplast DNA (Cronn et. al, 2003). The overwhelming consensus is that there is very little genetic diversity either within or between populations in Oregon.

The chromosome survey of Nygren (1954) examined populations of "*C. breweri"* ranging from Mono County (Tioga Pass) and Toulumne County (Tenaya Lake; Mt. Dana) in the central Sierra Range of California, northward to the Siskiyou Range (Alpine County, CA). Plants from the Sierra Range were determined to be tetraploid (2N = 4X = 28 chromosomes; now *C. muiriana*), while plants from the Siskiyou Range are hexaploid (2N = 6X = 42 chromosomes. Although the report of Nygren (1954) does not explicitly discuss the chromosome number for Oregon *C. breweri*, the distribution map (c.f. Fig. 4, page 391) in this publication clearly identifies the Mt. Hood population as "hexaploid". Chromosome counts have confirmed the hexploid status of this plant (Cronn, 2004).

Wilson and colleagues used isozyme methods to characterize the amount of genetic diversity of Oregon *C. breweri*, and the distinctiveness between northern hexaploid and southern tetraploid plants across their native range (Wilson et al., 1995; Wilson and Gray, 2002). The complexity of allozyme banding in these polyploid plants prevented the authors from analyzing their data using "locus-allele" models; instead, diversity estimates were derived from banding phenotypes from four enzyme systems (GOT, MDH, PGD, TPI). These approximations showed that individuals collected at Mt.

Jefferson (Jefferson Park; N = 18) were identical across the surveyed loci. Samples from Mt. Hood (Mt. Hood Meadows and Heather Canyon; N = 21) showed detectable variation. While the Mt. Hood population showed detectable variation, it's unclear how this variation is distributed among collection sites (Hood Meadows vs. Heather Canyon).

Recently, Richard Cronn (USFS-PNW) and Aaron Liston (Oregon State University) used two DNA-based methods to provide greater insight into the amount and apportionment of genetic diversity within and between the Mt. Jefferson and Mt. Hood populations (Cronn et al., 2003). The first method, Amplified Fragment Length Polymorphism (AFLP), provides estimates of variation in the nuclear genome at a relatively large number of loci. In theory, AFLPs should return a pattern of diversity similar to those obtained allozymes, but their higher variation, overall number, and greater genome coverage makes them more sensitive to population-level differences than allozymes, allowing better precision in estimates of closely-related groups. Results from AFLP generally mirror those obtained from allozymes, although AFLPs indicate a greater degree of interplant and interpopulation differentiation (Cronn and Liston, unpublished). (See Appendix C for details on the genetics of *Calamagrostis breweri*).

Genetic studies to date indicate that there is low, yet possibly significant, genetic divergence between C. breweri on Mt. Hood (Hood Meadows) and Mt. Jefferson. Based on the overall high degree of genetic similarity between these populations, one might expect that extirpation of either population would have negligible impact on the entire Oregon gene pool. However, molecular studies based on allozymes and DNA measure only selectively neutral genetic variation; as such, they typically show a poor correlation with quantitative and "adaptive" genetic traits (McKay and Latta, 2002). Subtle adaptations to local microhabitat and biotic conditions are best detected using common garden assessments of quantitative genetic variation (discussed in Appendix D). Until a study of this type is completed, it is important to preserve the full range of habitat diversity to ensure long term viability of the species in Oregon.

THREATS

Natural Threats

Herbivory and seed predation has been documented from sites on Mt. Hood and may have been carried out by insects, rodents and/or ungulates.

Outside the large-scale stochastic events such as pathogen outbreaks, massive slope failures, or resumed volcanic activity, the greatest natural threat to *Calamagrostis breweri* may be global climate change (for example, loss of snowpack, changes in moisture timing and condition, tree encroachment into *Calamagrostis* habitat). The low level of genetic diversity present in remaining *C. breweri* populations may be insufficient to enable adaptation to rapidly changing habitats and competition from encroaching vegetation.

Human-Related Threats

In Wilderness Areas

Over 50 percent of *C. breweri* sites in Oregon occur in wilderness areas on Mount Jefferson and Mount Hood. There are a number of factors that have led to habitat modification in areas where *C. breweri* plants are found. Historically, all of the areas had been grazed by domestic livestock (Nelson, 1991). Sheep have been absent from Mount Hood for about 100 years, and they were removed from the Willamette NF over 50 years ago. Only horses continue to impact the Wilderness Areas, with local and occasional grazing.

Both Mt. Hood and Mt. Jefferson experience high levels of recreational activity in and adjacent to *C. breweri* populations. Recreational activities (hiking, horseback riding, camping) cause trampling, compaction and erosion in populations that are accessible via the Timberline Trail from the south, east, north and northwest sides of Mt. Hood. There are many off-trail/user created trails through moist meadows where *C. breweri* is known to grow in both Mt. Hood and Jefferson Park. Areas immediately adjacent to the Jefferson Park lakes are most impacted by recreation visitors; large areas of vegetation have been damaged and modified from camping related activities. Evidence of *Calamagrostis breweri* plants lost due to trail disturbance and sloughing has been observed at Russell Lake. One study (VanderSchaaf 1982) focused on impact of backcountry use of wet meadows and found that vegetation was significantly altered and that certain plant communities (especially those sensitive to disturbance) declined significantly in local areas. Impacts on *Calamagrostis breweri* were not specified in the study.

Outside Wilderness Areas

On Mt. Hood approximately 85 acres of occupied *C. breweri* habitat occurs within the Mount Hood Meadows Ski Area. The ski area currently operates annually under a special use permit and in accordance with requirements specified in the 1997 Master Plan Record of Decision (ROD) and the Final Supplemental Environmental Impact Statement.

Over the years, impacts have been documented for *C. breweri* and its habitat in the Mt. Hood Meadows Ski Area; most of the following impacts occurred prior to the 1997 ROD: Construction of ski lift structures, buildings, and roads; development of slopes for ski runs (tree, rock, and woody debris removal); installation of culverts, diverting, bridging, or filling streams with wood to reduce ski hazards; operation of annual snow grooming machinery over habitat to optimize skiing conditions (may affect phenology during short growing seasons); operation of machinery to push snow into ski runs specifically to accommodate early and late season skiing, and salting ski runs over habitat areas to optimize skiing conditions (both activities may affect phenology during short growing seasons); operating brush mowing machinery through *C. breweri* habitat; some annual summer maintenance routines that involve off-road use of all-terrain vehicles; collection of native plant “shovel plugs” taken from *C. breweri* habitats in the vicinity of restoration projects (unapproved collections may interfere with data collection from monitoring plots). Populations located in moist meadows down slope of ski runs may have also been indirectly affected by changes in hydrology caused by the removal of trees and shrubs, and in some places by the diversion of streams.

The following are a few specific examples of impacts associated with ski area operations:

Texas Arena Site: A one acre site was modified by the construction of the Texas Lift in the 1970's. A stream was diverted to accommodate placement of the lift. A road was constructed through the habitat. A power line ditch was excavated down the center of the *C. breweri* site. As a result of these disturbances half of the wet basin habitat has dried and only a few *C. breweri* individuals remain in that area. A small population of *C. breweri* persists near the edges of a stream adjacent to the road, but the periphery of the site is both compacted and prone to erosion.

Speedwell Ski Run Wetland Site: *C. breweri* occurs in wetland habitat at the Mt. Hood Meadows base area west of the South Day Lodge. Between 1980 and 1985 construction of the Speedwell ski run disturbed a *C. breweri* site at the lower edge of the wetland. In 2003, Mt. Hood Meadows Corporation began plans to restore the impacted wetland site at the bottom of Speedwell Ski Run. If the restoration effort is successful, habitat for *C. breweri* may be restored as long as machines are annually restricted from the habitat area (including brush mowers).

Heather Canyon Site: *C. breweri* is located on a steep scree slope above Clark Creek in Heather Canyon. Throughout the ski season snow grooming equipment is winched down over the seep habitat to maintain desired skiing conditions; the effects of this action on *C. breweri* are unknown at this time and should be monitored. Snowfields in Heather Canyon are blasted regularly throughout the ski season to reduce the avalanche hazard for skiers; the residual impact that snow blasting might have on soil stability and associated hydrology at the site is presently unknown and should be monitored. In the last five years trees have been removed from riparian habitat along a narrow ridge (island) between two streams near the upper reaches of Heather canyon; the effects of this action are unknown at this time and should be monitored.

Ski Area Snow Modification

Winter related ski area activities such as snow modification (mechanical movement of snow from adjacent areas into the ski run to facilitate early and late season skiing, i.e. compaction of snow to create desirable skiing conditions) and the use of rock salt to enhance snow conditions, may have potential to impact *C. breweri* habitat.

Published studies of alpine species (Kudo, 1991) indicate that a major factor determining the survival and fecundity of alpine plant species is the length of the snow-free (growing) season. For example, grass species like *Deschampsia flexuosa* become evergreen if they grow in areas with short snow-free seasons, while they are often deciduous in areas with longer snow-free seasons. Other studies indicate that the length of the snow-free season greatly impacts the amount of carbon assimilated, and as a result, the ability of alpine species to reproduce (Bliss, 1971; Ingersoll, 1974). The rate of snowmelt also has an important impact on the distribution of all plants above timberline (Billings and Bliss, 1959).

The use of salt can also cause direct impacts to *C. breweri* populations. All areas where salt is applied to ski slopes drain into meadows that support the largest populations of *C. breweri.* It is not known whether salinity has increased in meadows that support populations of *C. breweri*. In 1997, a soil analysis was conducted to measure soil

salinity. The testing was done by the Agricultural Testing Laboratory of Umatilla, Oregon. Sampling took place in five ski run areas. They are named: 1) Daisy, 2) L Yellow, 3) R Yellow, 4) Wet Yellow, and 5) Panhandle). For all the areas but one (L Yellow), an additional control site was included. For each site, salinity was measured in sodium meq (milliequivalents), at two depths, 0-5” and 5-10”.

Table 2. Soil pH and salinity in selected sites on Mt. Hood National Forest

Site	Depth	pH	Na meq
Daisy	-5”	5.6	0.17
Daisy	-10”	5.5	0.13
Daisy Control	-5”	5.4	0.15
Daisy Control	-10”	5.4	0.16
R Yellow	-5”	5.2	0.14
R Yellow	-10”	5.3	0.11
R Yellow Control	-5”	5.4	0.10
R Yellow Control	-10”	5.4	0.15
L Yellow	-5”	5.5	0.16
L Yellow	-10”	5.6	0.13
Wet Yellow	-5”	5.6	0.13
Wet Yellow	-10”	5.7	0.13
Wet Yellow Control	-5”	5.4	0.07
Wet Yellow Control	-10”	5.6	0.08
Panhandle	-5”	5.5	0.14
Panhandle	-10”	5.4	0.13
Panhandle Control	-5”	5.1	0.11
Panhandle Control	-10”	5.2	0.08

Salinity data collected during this single year does not indicate a major difference in soil salinity between the control samples and samples within the ski runs in 1997. However, in order to conduct future biological evaluations of direct and indirect effects, periodic testing should be conducted.

An additional potential threat related to increased salinity and soil disturbance from ski area operations relates to the potential need for mycorrhizal fungal associations for long term viability and survival of *C. breweri*.

A preliminary study conducted by Cazares (1997) showed that all of the sites sampled in areas undisturbed by salinization and compaction had high rates of mycorrhizal colonization. The study also indicated that both the impacted areas and areas without *C. breweri* had significantly lower rates of colonization but still had some mycorrhizal fungi present. Two conclusions were drawn from the study: 1) There appeared to be lower rates of mycorrhizal fungi in the impacted areas than the unimpacted areas, but that additional research was needed to determine the cause of the impact, 2) Although lower rates of mycorrhizal fungi were found in impacted areas, the fact that at least *some* mycorrhizal fungi were present may indicate that restoration to un-impacted levels could be possible. However, the assessment only shows partial information and formulates a preliminary hypothesis that soil disturbances such as compaction and salinization cause a change in the habitat that affects the establishment of *C. breweri* and their mycorrhizal

symbionts. Additional work is needed to test specific hypothesis concerning the establishment of *C. breweri* in the Mt. Hood recreational area (Cazares 1997).

Potential Threats

The Oregon Department of Fish and Wildlife recently developed a proposal to introduce mountain goats into the Columbia River Gorge Scenic Area where they could potentially migrate to the Mt. Hood area. The potential impacts that wild goat reintroduction might have on *C. breweri* are unknown at this time and should be considered in future monitoring.

Horse use on trails and in or near meadows and campgrounds that intersect *C. breweri* habitat may be a source of disturbance to consider in future monitoring. The potential introduction of invasive non-native plants and noxious weeds via horse use of trails and camps near meadow and riparian habitats is an increasing concern although there are strict requirements for feeding while in,the wilderness.

Recreation along trails on the west and north sides of Mt. Hood also has potential to introduce invasive nonnative plants, especially on trails that are accessed from the Lolo Pass road where there are numerous documented sites of aggressive invasive non-native Orange (*Hieracium aurantiacum*) and yellow hawkweed (*Hieracium floribundum*) species. Both species are known to have a competitive edge as they quickly consume nutrients and moisture from the soil and inhibit the germination and growth of native plants.

Expansion of ski runs and facilities in alpine environments has been shown to cause erosion and other changes in vegetation patterns (Watson, 1985). Future threats may be related to proposed expansion of the Mt. Hood Meadows Ski Area into *C. breweri* habitats (occupied and/or unoccupied) that are currently outside of the existing ski area boundary, or proposed development to accommodate summer recreation throughout the ski area. Any future proposed expansion would be mutually designed by Mt. Hood Meadows and the Forest Service, taking into consideration the maintenance of *C. breweri* species viability.

MANAGEMENT RECOMMENDATIONS FOR HIGH PRIORITY SITES

Management Objectives

1. Maintain long-term viability of *Calamagrostis breweri* in its present range on National Forest Lands in Oregon.

2. Minimize the threats to all high priority sites of *Calamagrostis breweri* on National Forest lands in Oregon..

High Priority Sites

All known *C. breweri* populations were evaluated to determine whether they were necessary to maintain viability of the species on National Forest lands in Oregon. The desired future condition of sites selected as high priority is no impact to individuals or their habitat. Monitoring plots will be established at high priority sites to collect baseline data to use as control for future management.

There are fifty-five known sites on the Mt. Hood NF (see Appendix A). Twenty-one sites have been designated as high priority for management because they represent the full range of habitats and geographic locations for the species on the Mt. Hood NF and represent the healthiest populations on the Mt. Hood NF.

The only site on Willamette NF, Jefferson Park, is a high priority population.

Region-wide Management Recommendations (Mt. Hood and Willamette)

1. Monitor (see Monitoring Section) all designated high priority sites. Evaluate any new sites to determine if they meet criteria for selection as high or low priority sites.

2. Develop a site management plan for each high-priority site (similar sites may be lumped on the Mt. Hood NF. The plans will identify threats to populations and restoration and educational opportunities described in detail below.

3. Maintain or reduce recreational disturbance pressure on high priority sites using one or more of the following strategies:

   a. Enforce use of designated camp sites in Jefferson Park
   b.
   c. Consider limited use strategies in Jefferson Park, and other Wilderness areas experiencing high recreational use and associated natural resource damage
   d. Educate recreational users about habitat degradation from off-trail hiking and camping in non-designated areas through trailhead brochures and signs or other methods
   d. Wilderness Rangers educate recreational users about impacts they can have on C. breweri and report damage to specific sites from overuse.

4. Develop and implement plans for restoration of habitat and *Calamagrostis breweri* reintroduction, for example at Texas Arena in Mt Hood Meadows and around Russell Lake in Mt. Jefferson Wilderness (restoration will have to be consistent with Wilderness policy). Part of this will include determination of whether plant material from different locations expresses genes differently when grown in a common ecosystem (initiate and complete common garden study=-Appendix D) to determine whether material from Mt. Hood and Mt. Jefferson can be reciprocally transplanted.

5. Prepare educational materials for wilderness visitors explaining how inadvertent introduction of non-native species (via hiking boots, clothing, camping gear, horses, etc.) is a threat to the integrity of wilderness ecosystems and plant communities that support rare plants. The intent is to encourage users to clean hiking and camping gear, horses and associated gear, between trips and before entering Wilderness. Horse owners should be encouraged to follow the existing protocol regarding feeding only weed-free forage on Forest Service lands.

6. Actively seek funding and cooperators to implement Future Research suggestions (see below).

7. Remove non-native species if they are found in *C. breweri* habitat in the wilderness area. If habitat requires restoration, temporary signs should be posted around the habitat to restrict entry until restoration is accomplished.

8. Review the Conservation Strategy at least once every 10 years and revise as necessary to include new information, additional site locations and pertinent management strategies.

<u>Forest Specific Management Recommendations</u>

Mt Hood National Forest

1. Avoid impacts to *C. breweri* populations through project design, placement of structures, and machine activity (MHM EIS, page A7 - 6).

2. Buffer zones that are approved by the District Botanist will be established around *C. breweri* on a site-specific project basis, with an average buffer of 200 feet from habitat edge (MHM EIS, page A7, 6.)

3. Establish minimum snow depths for both winter and summer skiing to protect vegetation from mechanical and salt effects (MHM EIS, page A7 - 7).

4. Avoid dispersed trampling of plant communities through construction of formal paths in heavy use areas and through other approved means (MHM EIS, page A7 – 4).

5. Monitor populations of *C. breweri* annually to evaluate population stability and to assess effects of ski area maintenance (MHM EIS, page A7 – 6).

6. Complete a Restoration Plan for designated high priority sites in the ski area and in the wilderness. This plan would include a prioritization of sites, a

revegetation plan (including specifications regarding C. breweri seed collection), a weed control plan and a timeline for implementing the plan. The plan will be completed cooperatively with Mt. Hood Meadows where populations overlap with their special use permit. Mt. Hood Meadows would be expected to share in the cost of plan development and implementation as part of their special use permit.

7. Complete a Monitoring Plan. Monitoring should follow specific protocols identified in this document. Establish monitoring plots at designated high priority sites. Evaluate all new populations that are found on Mt. Hood to determine if they meet criteria for selection as high or low priority sites.

   Include *C. breweri* populations and suitable habitats where machinery is used to groom or move snow and ski runs where salt is applied in the monitoring plan.

   Resume collecting data from monitoring plots that were established in 1996 at sites in Cairn Basin, Wyeast Basin, Elk Cove, and Paradise Park.

   Sites that are intersected by trails that originate from Lolo Pass Road should be monitored annually for noxious weeds and recreation impacts.

8. Collect seeds of C. *breweri* and associated native species from selected sites within the Mt. Hood Meadows Permit Area (MHM) with guidance from the Hood River district botanist. The native seeds that are collected should be used for restoration of suitable habitats that will be identified during the next five years. A USFS botanist will provide Mt Hood Meadows with a map of collection sites and appropriate time for collection.

9. Review the annual operating plan for Mt. Hood Meadows every year to ensure that standard operating procedures do not conflict with the management of *C. breweri* in the ski area.

INVENTORY

On the Mt. Hood National Forest during the mid- 1990's surveys for *C. breweri* were conducted in most meadow habitats that were relatively accessible by trails on the north, west, and east side of Mt. Hood. Since the mid-1990's there has only been one additional survey and one site found near the Mt. Hood Wilderness on the north side of the mountain. Surveys were also conducted in approximately 70% of meadow habitat within the Mt. Hood Meadows Ski Area (surveys in the Mt. Hood Meadows Ski Area have typically only been conducted for proposed project related activities).

Additional inventories are needed on Mt. Hood to accurately describe the distribution of *C. breweri*. Inventories should include suitable habitat that has not been surveyed in the past particularly on the south and southwest side of Mt. Hood and between known populations around the mountain.

Inventory of *Calamagrostis breweri* on the Willamette National Forest has been limited to mapping of site locations in the Jefferson Park area (Mt. Jefferson Wilderness). Since the initial mapping of this population in 1990, many additional visits to Jefferson Park have yielded location of only a few additional isolated sites. From 2000-2005, surveys were conducted at Jefferson Park to GPS the extent of *Calamagrostis breweri*.

We recommend inventory of other high probability habitats between Mt. Jefferson and the northern California populations to determine whether there are more sites in Oregon (see future research section).

MONITORING

Population monitoring on the Mt. Hood National Forest has been limited to several high priority sites within the Mt. Hood Meadows Ski Area, and several sites in the Mt. Hood Wilderness. Sites that were mapped in the mid-1990's had rough counts of flowering stems, associated species and visible disturbances. Population monitoring of *Calamagrostis* on the Willamette National Forest has been limited to rough number counts in Jefferson Park.

Monitoring Goals

The monitoring goals for this Conservation Strategy are to:

1. Develop baseline information on high priority populations across the range to be used to assess if/when active management is required to maintain populations and
2. Determine which current and future threats could adversely affect populations and attempt to quantify adverse effects (this information will be used in site management plans).

Monitoring Objectives

1. Collect baseline data on habitat condition, complete species inventory and abundance.

2. Assess reproductive effort within selected populations to document viability concerns over time

3. Assess effects of various disturbances (recreation, ski area management) on species reproduction and viability.

4. If high priority populations decrease by 30% or more in a single year, annual monitoring will be instituted.

5. If populations decrease by 50% or are decreasing annually, active management through habitat restoration or species reintroduction will be triggered.

Two types of monitoring will be used to achieve monitoring objectives: defensibility monitoring and population monitoring.

Defensibility monitoring is revisiting populations to determine that they are still extant. This type of monitoring is often complemented with permanent photopoints that can be used to document changes in habitat.

Population monitoring is designed to follow representative subpopulations over time to determine the natural range in variability of population size and reproductive effort.

Initial inventories will map populations and document any disturbances occurring in populations. Plots will be chosen at random and stratified by disturbance type, if any. A select number (depending on population size and distribution) of 5m x 1m permanent belt transects will be established where densities of *Calamagrostis breweri* are documented. Descriptive data including plant cover, number of flowering stems, associated plant community, and signs of disturbance will be collected (see Appendix E for Monitoring Forms). Data from monitoring will be compared in an effort to detect a percentage change in cover values, and any trends developing in seed production, community affiliation, and disturbance patterns.

Mt Hood NF Monitoring Sites

On the Mt. Hood, a schedule for population monitoring in high priority sites will be developed and will result in approximately 4 populations monitored per year. Three of the populations will be in the Mt. Hood Meadows Permit Area and one in the Wilderness.

It would be useful if additional populations were monitored using the defensibility monitoring protocol. Due to current and predicted financial constraints this effort is likely to be completed by volunteers.

Willamette NF Monitoring Site

In Jefferson Park, both defensibility monitoring and population monitoring will occur.

Defensibility monitoring will take place in outliers within the Jeff Park population on Park Ridge and Breitenbush Trail. Monitoring will occur every 5 years.

Population monitoring at Jefferson Park will consist of four permanent transects within the central part of the population (around the Russell Lake area). Two transects will be placed adjacent to designated camping sites and two transects placed adjacent to established trails, in order to assess disturbance due to heavy recreational use of camping around lakes and effects of non-system trail development.

FUTURE RESEARCH

Research is critical in helping quantify and categorize the threats to *C. breweri* . Information will be used to develop and implement mitigation strategies to reduce possible impacts. In addition, sensitive species policy and the National Environmental Policy Act require an "effect determination" which includes analysis of direct effects, indirect effects, short and long term effects, and cumulative effects. There is insufficient information and baseline data to support conclusions regarding the significance of potential effects that ski area management activities might have on *C. breweri* and its habitat.

Studies should be established at high priority sites (beginning in 2010) on the Mt. Hood National Forest to gather data that may be helpful to assess potential direct, indirect, short term, long term and cumulative effects of snow management. Studies should also be established at designated high priority sites on Mt. Hood and Mt. Jefferson to gather data that may be helpful to assess potential direct, indirect, short term, long term and cumulative effects of recreation

Role of Disturbance in *C. breweri* Establishment and Survivorship

1. Determine role open ground/ disturbance plays in seedling emergence/establishment success.
2. Determine extent of adverse effects from recreational hiking and camping on population size as well as from competition/encroachment (is there net loss?)

Impacts of Snow Management to *C. breweri* in the Mt. Hood Meadows Ski Area

1. Are there differences in "health" of *C. breweri* plants, habitat, and essential mycorrhizal association in the ski area and outside of the ski area?

2. Does compaction of snow have an effect on the phenology of *C. breweri*?

3. Does the use of salt on ski runs in the vicinity of *C. breweri* sites affect the snowmelt and associated phenology of *C. breweri*?

4. Does blasting of snow (necessary for avalanche control) effect *C. breweri* habitat?

Role of Soil Biology in *C. breweri* Distribution

One of the most frequently asked questions regarding the patchy and disjunct distribution of Oregon *C. breweri* is why this species is not found in high elevation wilderness areas between Mt. Jefferson in the north and Mt. Shasta in the south? If the populations on Mt. Jefferson and Hood are relatively recent (Quaternary) introductions from a more distant geographic source, then the present-day distribution can be simply explained as one of chance; *C. breweri* has not become established in other suitable habitats because of the rarity of these long-distance dispersal events. Alternatively, the absence of *C. breweri* in these high elevation sites may be an indicator of subtle habitat or substrate differences; that is, these habitats may be sufficiently divergent from

"typical" *C. breweri* habitat that propagules perform poorly and fail to become established. One way to assess this question would be to collect soils from known *C. breweri* habitat on Mt. Hood and Jefferson (and possibly Mt. Eddy in the Siskiyou NF) to similar habitat types in Three Sisters (Willamette NF), Mt. Thielsen (Umpqua NF), Sky Lakes (Rogue River NF) and Mt. Shasta (Shasta-Trinity NF) Wildernesses and determine whether seeds would grow in soil from these sites. If not, deficiencies in key mycorrhizal symbionts or nutrients may be responsible for the limited geographic distribution of *C. breweri*.

Ability to Transplant C. breweri from population to population (Common Garden Studies)

Set up common garden experiments in an accessible, high elevation setting to determine whether there are quantitative differences in *C. breweri* from Mt. Hood and Jefferson. Traits of greatest importance would be those relating to reproductive fitness (flowering date, fertile flowers per inflorescence, pollen viability, seed set or fecundity), although growth and vigor traits would be relevant. While a common garden study would best be accomplished using soils derived from an existing *C. breweri* site (noting prior questions regarding microflora or nutrient requirements), it would be best to locate this study distant from either the Mt. Hood and Mt. Jefferson populations in case of seed or pollen escape and subsequent cross-locality hybridization. If significant adaptive differences do exist between these populations, then they should be kept separate to maintain this population-level distinction and to prevent the creation of maladapted gene combinations.

Realized and Potential Distribution of *C. breweri*

The patchy distribution of *C. breweri* raises questions about how the species was initially introduced to Oregon, and whether it has the capacity to migrate to new locations in response to stress. The integration of GIS with survey/census and genetic information may shed new light on these scenarios. Integrating spatial and climatic data may help botanists focus their survey efforts on promising localities, possibly extending the known range of *C. breweri* in the Oregon Cascades. Finally, if a close correspondence is observed between observed localities and one or more climatic variables (e.g., frost-free days; average minimum temperature), GIS approaches may allow land managers to identify new sites for introduction; this may be especially beneficial if climate change leads to greater encroachment of trees in meadows or changes in snow and/or water regimes in areas that presently harbor *C. breweri*.

ADAPTIVE MANAGEMENT

Data Analysis and Triggering of Management Action

Data from monitoring will be gathered every other year for the first 10 years. After this baseline and initial data are collected, a review will determine whether the monitoring design should be modified to better meet objectives, and determine whether an appropriate level of population decline to trigger further management action has been designated in the strategy

Review of Conservation Strategy and Status.

The following would trigger a review of the Strategy:

1. New populations documented during surveys on Mt. Hood NF or between Mt. Jefferson and northern California population
2. Monitoring results showing a decline in populations across the Region
3. Loss or alteration of 3 low priority sites on Mt Hood due to management would trigger a review of the high and low priority sites.

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APPENDIX A: HIGH PRIORITY SITES ON MT. HOOD NF

Prioritization for Site Management

There are fifty-nine known sites on the Mt. Hood NF. Twenty-one sites have been designated as high priority for management because they represent the full range of habitats and geographic locations for the species on the Mt. Hood NF. Some represent the healthiest populations on the Mt. Hood NF. The remaining thirty-eight sites are low priority because the habitat characteristics of the sites are well represented in nearby high priority sites, and/or some of the sites have been previously impacted to a degree that the habitat conditions are no longer optimum for the species. New sites that are found outside of management areas will be reviewed to determine if the site meets criteria for high or low priority management

High priority = Populations will be managed so there will be no impact to individuals and habitat. Establish monitoring plots at selected sites to collect baseline data to use as control for future management. High priority sites are chosen because they have:

1. Habitat characteristics that represent a wide range of elevation, various slope aspects, topographic position, and locally peripheral or isolated geographic locations, and a combination of most unique and most common micro-site components.

2. Large or small sites in the vicinity of relatively similar sites, in which case high priority sites are selected based on overall health of the population and integrity of habitat.

Low priority = May allow the impact of low priority sites if the Biological Evaluation Process documents there will be no loss of viability of the species as a whole on the Mt. Hood National Forest or throughout the range of the species. Low priority sites include:

1. Large or small sites with common habitat characteristics that are represented in nearby high priority sites.

2. Sites in the Mt. Hood Wilderness Area that are not presently threatened by recreation or other management activities (i.e., sites that are not along trails or travel routes).

3. Small sites within Mt. Hood Meadows Permit Area that have been fragmented from larger populations by development of the ski area during the 1970's and 80's. The sites may have been impacted to a degree that the habitat is no longer optimum for sustaining viability of the site (i.e., dry soil conditions and dry site plant associations resulting from alterations to some riparian areas and wet meadows).

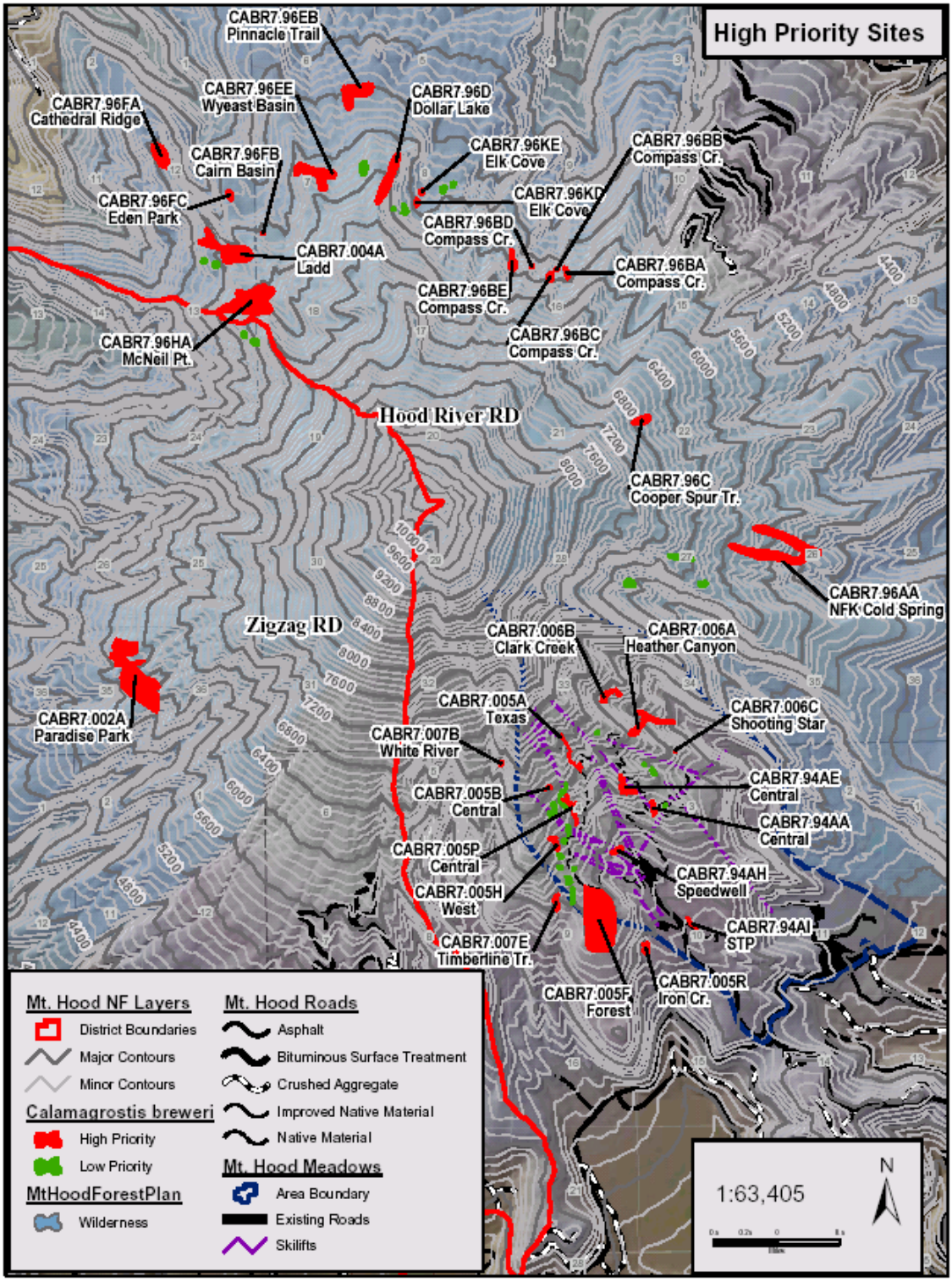

Figure 6. High and low priority populations on the Mt. Hood National Forest

High and Low Priority populations on Mt. Hood NF

High Priority (see Figure 6)

Sites Within the Mt. Hood Meadows Permit Area:

a. Texas Arena – site #005.a:
This particular *C. breweri* site represents the northernmost occupied habitat in the Mt. Hood Meadows (MHM) Permit Area. At 6800' it is the highest elevation site on south/southeast side of Mt. Hood NF.

b. Heather Canyon – North Fork of Clark Creek - sites # 006a and 006e:
Site #006a is located on a steep (75%) scree slope above Newton Creek. The site is unique because it is the only known scree/seep habitat occupied by *C. breweri* on Mt. Hood and Mt. Jefferson. Site # 006e is located down slope (below site #006a) along Clark Creek and up into adjoining forested islands. These sites represent the northeastern edge of the *C. breweri* population within the Mt. Hood Meadows Permit Area.

c. Hood River Meadows – site # 94B:
This site is located in a small wet meadow between the top of Hood River Meadows Ski Lift and the headwaters of the south branch of Clark Creek. The site is of interest because it is isolated from the nearest known sites 1 mile away and because it is located at the easternmost edge of the Mt. Hood Meadows Permit Area.

d. Timberline Trail – site #007a:
C. breweri has been found in a large meadow/seep northwest of the junction of Umbrella Falls Trail and Timberline Trail. The site is of interest because it represents healthy wet meadow habitat characteristics that are common in smaller sites nearby, and because it is the largest site at the western edge of Mt. Hood Meadows Permit Area.

5. Central MHM Permit Area – sites #9401, 9416, 9423, and 93.1: The largest concentration of sites occurs in the mid-elevation meadows, seeps, and riparian areas in the west-central portion of MHM Permit Area. Most of the sites are small and fragmented by previous ski area construction activities. Site #9401, at 6500' (northwest above the Red Lift) is the highest elevation site in the west central portion of the MHM Permit Area. Site # 9416 (near the top of the Red Lift) is the largest site near the central western edge of the MHM Permit Area. Site # 93.1 is the next largest centrally located site near the headwaters of a tributary to the East Fork of the Hood River (near the Mt. Hood Express Ski Lift). Site #9423 is the largest of the fragmented sites near the eastern central portion of the Mt. Hood Meadows Permit Area.

6. Speedwell Ski Run Wetland - site #94AH:
C. breweri occurs in a wetland near the base of the Blue Ski Lift at the Mt. Hood Meadows base area west of the South Day Lodge. At 5200' it is the lowest elevation site within in the Mt. Hood Meadows Permit Area.

Sites Outside of the Mt. Hood Meadows Permit Area:

7. Mitchell Creek Headwaters - site # 005f:
This site is located on the south side of Mt. Hood along a forested ridge between the headwaters of a west fork tributary to White River and headwaters of Mitchell Creek in the White River Wild and Scenic Area directly southwest of the Mt. Hood Meadows Permit Area (MHM). It is the second largest site on Mt. Hood. The site is unique because it is the only known occupied forested ridgeline habitat on Mt. Hood

8. North Fork Iron Creek Headwaters – site # 9508 (subpopulation of site #005f):
This site is located on the south side of Mt. Hood in the White River Wild and Scenic River Area directly southwest of the MHM Permit Area. The site represents the southernmost edge of the population on the Mt. Hood NF, and at 5000' it is the lowest elevation site on the south side of the mountain.

9. White River Headwaters – site # 9506:
This site is located on the south side of Mt. Hood at the headwaters of the White River in the White River Wild and Scenic River Area. The site is of interest because it is isolated from the nearest known site over 1 mile away to the east, and 2 miles away to the south. It is the westernmost site on the south side of Mt. Hood, and at 6500' it is one of the highest elevation sites on the Mt. Hood NF.

10. Paradise Park – site # 9617 and 9618:
Both sites are of interest because they are the only known sites on the west side of Mt. Hood and because they are isolated from the nearest known site over 2 miles away to the north, and over 3 miles away to the southeast. Site # 9617 is farthest west at an elevation of 5400'; it is located directly adjacent to the Timberline Trail. Site # 9618 is the larger of the 2 sites, and is located in Paradise Park at an elevation of 6000'. Site # 9617 is presently the largest known site on Mt. Hood.

11. Cathedral Ridge – site # 9619:
The site is located on the northwest side of Mt. Hood adjacent to the Cathedral Ridge Trail (625) at 5000'. It is presently the northernmost site on the Mt. Hood NF.

12. Gibson Glacier / McNeil Point – site # 9623, A, B, and C:
There are 3 subpopulations at this site; site A is the largest. At 6400' site C is the highest elevation site on the northwest side of Mt. Hood.

13. Cairn Basin – site # 9511, Eden Park – site # 9510, WyEast Basin – site #s 9613, 9512 and 96.4, Elk Cove – site # 9616:
Six sites and subpopulations are located in meadows along the main trail route on the north side of Mt. Hood. The sites are of interest because 1) they are located in meadow habitats that are typical on the north side of the mountain and 2) previous monitoring at the sites have reported impacts from trampling and compaction in the meadows.

14. Compass Creek Headwaters – site # 9606:
Five small subpopulations are located in the steep headwaters of Compass Creek on the northeast side of Mt. Hood at 6000'. The sites are isolated from the nearest known site over 1 mile to the northwest and over 1 mile to the southeast.

15. Cooper Spur Trail – site # 9611:
The site is located adjacent to the Timberline trail on the east side of Mt. Hood. At 6800' it is the highest elevation site on the east side of the mountain. The site is of particular interest because it is isolated from the nearest site almost 2 miles to the north and over a mile and a half to the south.

16. North Fork of Cold Spring Creek – site # 9612:
The site is located in seeps and wet meadows at the headwaters of the North Fork of Cold Spring Creek between 5400' and 6400'. It is the easternmost known site on the Mt. Hood NF. It is the third largest known site on Mt. Hood.

Low Priority (see Figure 6)

Includes all presently known sites that are not designated at this time as high priority. Some low priority sites may be moved to High Priority at any point in the future if further studies indicate that they may have significant value in maintaining viability of *C. breweri* on the Mt. Hood NF.

Table 3: List of Selected Populations on Willamette and Mt. Hood NFs.

Population Name	ORNHIC Element Occurrence or Forest ID Number	Population Size	Land Use Allocation	Unique features	Threats – Existing and Potential
Mt. Jefferson Park	003		Mt. Jefferson Wilderness	Only population on Willamette NF	Trampling, compaction, erosion
Texas arena	005	+/- 1000 clumps on approx. 1 acre (1996)	Mt Hood Meadows Permit Area	6800'; highest known site on SE side of Mt. Hood	Summer & winter ski area maintenance
Heather Canyon	006a	+/- 700 clumps on ¼ acre (1996)	Mt Hood Meadows Permit Area	Only scree/seep habitat in Oregon	Winter ski area maintenance
North Fork of Clark Creek	006e	+/- 500 clumps on 1 acre (verify)	Mt Hood Meadows Permit Area	Along creek and into forested habitat	Winter ski area maintenance
Hood River Meadows	94B	+/- 500 clumps on ¼ acre (verify)	Mt Hood Meadows Permit Area	Isolated population; eastern edge of permit area	unknown
Timberline Trail	007a	Estimate at least 1000 clumps on approx. 1 acre (1996)	Mt Hood Meadows Permit Area	Healthy wet meadow habitat; largest site at west edge of permit area	Trampling, compaction, erosion[1] and Winter ski area maintenance
Central MHM Permit Area	9401, 9416, 9423, and 93.1 (CABR7.94A & B)	+/- 2000 clumps on 4 acres	Mt Hood Meadows Permit Area	Selected for size and elevation ranges	Winter Recreation
Speedwell Ski Run Wetland	94A	<500 clumps on ½ acre (verify)	Mt Hood Meadows Permit Area	5200'; lowest site in permit area	Summer and winter ski area maintenance
West tributary to Iron Creek Mitchell Creek Headwaters	CABR7.007	+/- 3000 clumps on 3 acres (1996)	White River Wild and Scenic Area	Second largest site and only pristine forested ridgeline habitat on Mt Hood	Potential ski area expansion
North Fork Iron Creek Headwaters	9508	+/- 1000 clumps on approx. 2 acres (1996)	White River Wild and Scenic Area	Southernmost edge and lowest elevation, 5000', on Mt Hood	Potential ski area expansion
White River Headwaters	9506	<500 clumps (verify)	White River Wild and Scenic Area	Westernmost on south side of Hood and one of highest at 6500'	Potential ski area expansion
Paradise Park	9617 and 9618 (.002 in 1926)	> 4000 clumps on 4 acres	Mt Hood Wilderness	Westernmost sites on Mt. Hood; 9617-largest known site on forest, 5400'; 9618 is at 6000'	Trampling, compaction, erosion
Cathedral Ridge	9619	Verify	Mt Hood Wilderness	5000', northernmost population on Mt. Hood NF	Trampling, compaction, erosion
Gibson Glacier / McNeil Point –	004 (HR96-23 A, B, and C)	Verify	Mt Hood Wilderness	6400' highest on nw side Mt Hood	Trampling, compaction, erosion
Cairn Basin	9511 and 12 (HR96 E, F)	+/- 100 clumps on approx. ½ acre (1995)	Mt Hood Wilderness	Representative meadow habitat	Trampling, compaction, erosion
Eden Park	9510 (HR96FC)	+/- 1000 plants on approx. 3 acres (1995)	Mt Hood Wilderness	Representative meadow habitat	Trampling, compaction, erosion
WyEast Basin	9512, 9613, , and 96.4	+/- 3000 plants on approx. 3 acres (1995)	Mt Hood Wilderness	Representative meadow habitat	Trampling, compaction, erosion

Population Name	ORNHIC Element Occurrence or Forest ID Number	Population Size	Land Use Allocation	Unique features	Threats – Existing and Potential
Elk Cove	9616	+/- 100 clumps on approx. ½ acre (1995)	Mt Hood Wilderness	Representative meadow habitat	Trampling, compaction, erosion
Compass Creek Headwaters	9606 (CABR7.96B)	+/- 100 clumps on approx. ½ acre (1995)	Mt Hood Wilderness	Isolated. Northeast side Mt. Hood, 6000'	Trampling, compaction, erosion
Cooper Spur Trail	HR9611	15m x 3m (1996)	Mt Hood Wilderness	Isolated. East side Mt Hood, 6800'	Trampling, compaction, erosion
North Fork of Cold Spring Creek	9612	+/- 100 clumps on approx. ½ acre (1995)	Mt Hood Wilderness	Easternmost, 3rd largest, seep and wet meadow habitat	Trampling, compaction, erosion

APPENDIX B: SPECIES ASSOCIATED WITH *C. BREWERI* HABITATS

Other species recorded from Oregon sites are:

Trees
Abies lasiocarpa
Pinus albicaulis
Tsuga mertensiana

Shrubs
Cassiope mertensiana
Gaultheria humifusa
Ledum glandulosum var. *californicum*
Salix species
Vaccinium deliciosum

Graminoids
Agoseris aurantiacus

Luzula hitchcockii
Scirpus criniger
Trisetum spicatum

Forbs
Achillea millefolium
Antennaria rosea
Arnica latifolia
Castilleja parviflora var. *olympica*
Castilleja suksdorfii
Cystopteris fragilis
Dodecatheon conjugans
Dodecatheon jeffreyi
Epilobium glaberrimum
Eriogonum umbellatum ssp. *hausknechtii*
Eriophyllum lanatum
Erythronium montanum
Gentiana newberryi
Hypericum anagalloides
Ligusticum apiifolium
Ligusticum californicum
Lomatium martindalei
Lupinus lepidus
Mimulus guttatus
Parnassia fimbriata
Peducularis groenlandica
Penstemon davidsonii
Polygonum newberryi ssp. *newberri*
Saxifraga ferruginea ssp. *macounii*
Saxifraga tolmei ssp. *tolmei*
Spiraea densiflora

Tofieldia glutinosa ssp. *occidentalis*
Veratrum viride
Veronica wormskjoldii
Viola palustris
Xerophyllum tenax

APPENDIX C: DETAILS OF GENETIC STUDIES ON *CALAMAGROSTIS BREWERI*

Within Oregon, the Hood and Jefferson populations of CABR show large differences in variability. Plants from Mt. Hood exhibited the highest overall variation, with 65 variable AFLP markers and an estimated heterozygosity of 0.1511. Thirteen of the 42 samples showed genetic distances that were indistinguishable, a finding that might point to a modest degree of clonality in this population. Plants from Mt. Jefferson show fewer variable markers (36) and lower estimated heterozygosity (0.0939) than the Mt. Hood population. Based on AFLP estimates of allele frequencies, Hood Meadows and Mt. Jefferson populations of *C. breweri* show significant differences in the apportionment of genetic variation. Estimates of population subdivision based on expected heterozygosity (F_{ST} = 0.159) and variance in allele frequencies (ϕPT = 0.154) indicate that this level of subdivision is significant (P < 0.001). The distinctiveness of these two populations can be revealed by as few as three AFLP bands (*Pst*ACA-*Mse*GAT 117 bp; *Eco*ACA-*Mse*GAT 133 bp and 269 bp). It should be noted that while differences between the Mt. Jefferson and Mt. Hood populations are evident, inter-plant genetic distances within populations showed no correlation with geographic distances up to 1.5 km. These results indicate that there may be a high degree of pollen and/or seed movement within populations, but that the Mt. Hood and Mt. Jefferson populations are effectively isolated with regard to gene flow. In light of evidence indicating genetic differentiation between *C. breweri* from Mt. Hood and Mt. Jefferson, attempts should be made to maintain the distinctiveness of these populations, and seed should not be transferred between these locations.

A second DNA-based analysis using chloroplast (cp) DNA variation has provided insights into the extent of hidden variation in the maternally-inherited, cytoplasmic chloroplast genome of *C. breweri* (Cronn and Horning, unpublished). Variation in cpDNA is known to play a role in disease resistance and hybrid fertility (summarized in Burke and Arnold, 2001), and cpDNA variation cannot be revealed with allozymes or AFLPs. Critically, since cpDNA is haploid, it can be compared across species with different nuclear ploidy levels (e.g., 6X *C. breweri* vs. 4X *C. muiriana*) without simplifying assumptions.

Surveys of cpDNA variation in *C. breweri* and *C. muiriana* focused on ~4.1 kilobases of non-coding DNA, including three intergenic spacers (*atpB-rbcL; trnL-trnT; trnT-trnL*) and two introns (*rpl16; trnK*). Populations included in this survey were Oregon *C. breweri* (Mt. Jefferson, N = 40; Mt. Hood, N = 40), Californian *C. breweri* (Siskiyou and Trinity Ranges, N = 31) and *C. muiriana* from Tioga Pass, CA (N = 13). This survey revealed six chloroplast haplotypes, five from tetraploid *C. muiriana*, and a single haplotype from *C. breweri* in Oregon and northern California (figure 7A). These results are significant, as they suggest that *C. breweri* from Mt. Hood, OR to Mt. Eddy, CA constitute an allohexaploid lineage that traces to a recent, common maternal ancestor. There are two possible explanations for this finding (figures 7B, 7C). First, if the formation of 6X *C. breweri* occurred in the recent past (e.g., last 0.1 - 0.5 million years), it's possible that insufficient time has passed for novel chloroplast variants to arise in this species. In this scenario (Fig. 7B), the genetic bottleneck imposed by polyploid formation would be evident in *all* extant *C. breweri*;. Alternatively, *C. breweri* may have radiated through a series of successive dispersal events, first from the Sierra Range, next to the Siskiyou area, and finally to the Oregon Cascades. These events would have imposed an ever-

increasing bottleneck on genetic diversity, as illustrated in Fig. 6C, A survey of cpDNA diversity in *C. breweri* from the Sierra Range would permit a formal test of these hypotheses.

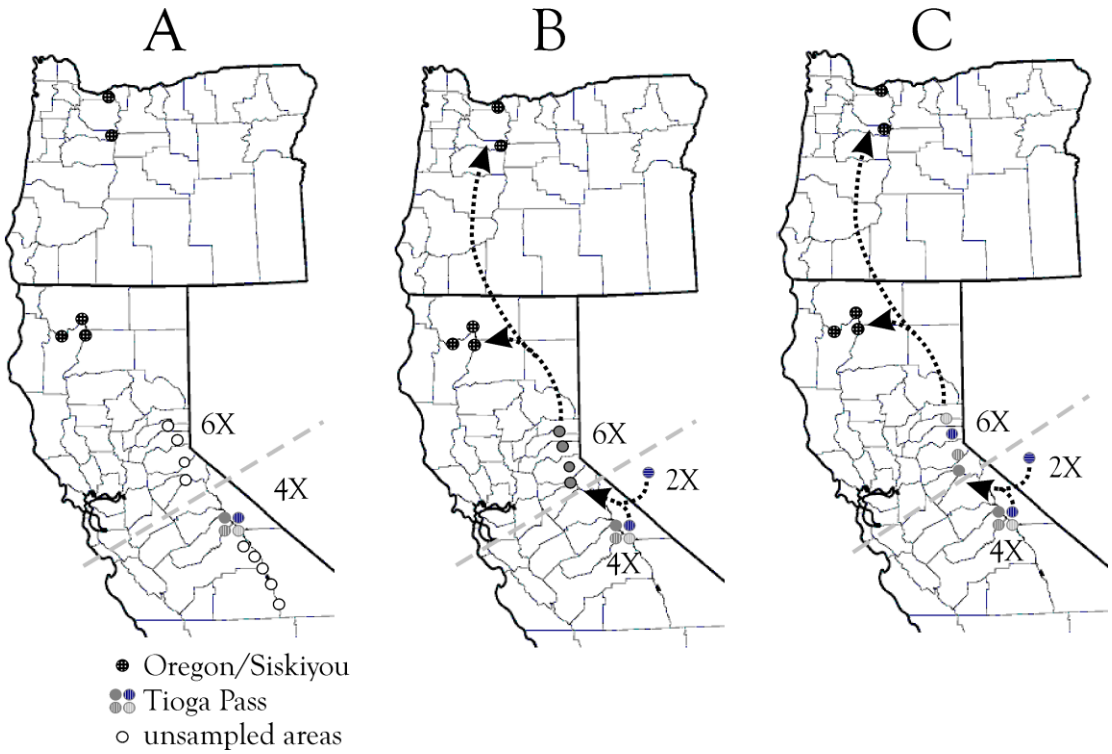

Figure 7: Chloroplast haplotype distributions for *Calamagrostis breweri* and scearios explaining the absence of diversity.

A) Haplotypes found in present-day C. breweri [6X; circles] from Oregon and California, and C. muiriana [4X; diamonds] from Tioga Pass, CA. Unsampled regions of C. breweri and C. muiriana range are shown as unfilled shapes. B) In the "recent polyploidization" scenario, C. muiriana and an unknown diploid [2X] hybridized to create the hexaploid lineage. Due to the recency of this event, all C. breweri would be fixed for a common haplotype. C) In the "successive dispersal" scenario, C. muiriana and the 2X parent hybridized in the sufficiently distant past that novel haplotypes arose in C. breweri. Long-distance dispersal events are responsible for the lack of detectable variation in cpDNA from northern California and Oregon.

Irrespective of the events that created present-day *C. breweri*, Oregon populations show low levels of genetic diversity, and the populations at Mt. Hood and Mt. Jefferson show significant differentiation. Based on AFLP and cpDNA variation, *C. muiriana* from a single meadow at Tioga Pass, CA possesses two-fold more nuclear genetic diversity and five-fold more chloroplast genetic diversity than *all C. breweri* in Oregon. The limited genetic diversity and potential isolation of Oregon *C. breweri* raises questions as to whether inbreeding could lead to declines in plant fitness or population viability. In this regard, the allohexaploid genome of *C. breweri* may provide an effective buffer

against inbreeding depression, since it contains three diploid genomes in a nucleus. Genetic theory (Grant, 1975; Soltis and Soltis, 2000) suggests that allopolyploids are less likely to suffer from inbreeding depression than related diploids since the genetic redundancy created through polyploidy compensates for potentially deleterious alleles. Allopolyploids like *C. breweri* are often described as “fixed heterozygotes”, since they are heterozygous for all loci in the genome, and since this heterozygosity cannot be eliminated by normal genetic processes (e.g., recombination, segregation). In simple terms, *C. breweri* has three functional, complementary, and interchangeable copies of every gene in its genome. While *C. breweri* in Oregon lacks genetic variation at the population-level, each plant has 50% more allelic diversity than a fully heterozygous diploid individual from a related species. For this reason, impacts from inbreeding should be of minimal concern.

APPENDIX D: COMMON GARDEN STUDY TO EVALUATE QUANTITATIVE GENETIC VARIATION IN *C. BREWERI*

Objective

The objective of this section is to outline a common garden study for the purpose of identifying seed transfer guidelines for alpine reedgrass in Oregon. This study should provide insight into the extent of quantitative genetic variation both within- and among seed sources in Oregon. If source differences are apparent, patterns of genetic variation over the landscape can be evaluated and used to establish seed movement guidelines for this rare species

Methods and Materials

Seed Collection

Ideally, seed samples should be obtained from maternal plants that are as evenly spread out as allowed by the distribution of species. "Populations" are defined as a group of maternal plants sharing a distinct origin (lake or drainage); ideally, populations should be separated by at least 100 meters. If possible, collections will sample the range of elevation and habitat occupied by *C. breweri*.

At each population, seed will be collected from four non-identical maternal plants, and seed will be maintained separately for each maternal plant (*not bulked*). This sampling will allow for genetic variation to be partitioned into within and among sources. To minimize redundant sampling of clones, maternal plants should be separated by about 5 meters. When collecting seeds, populations could be assigned a 3-digit number, followed a fraction identifying the maternal plant within the site (e.g. 1/4 for the first of four maternal plants from that site). Seeds should be stored at room temperature until time of sowing.

Latitude, longitude, and elevation should be recorded for each sample location. These locations can then be classified by seed zones (USDA 1973), soil type (based on National Forest Soil Resource Inventory maps), ecoregion (Level IV, Omernik 1987, 1995), USGS watershed stratification (HUC5) and plant association vegetation grouping (Johnson and Clausnitzer 1992). Locations should also classified as "wet" or "dry" (mesic or xeric) based on proximity to surface or other microsite conditions. Climatic conditions at seed collection sites can be characterized using digital maps and data generated by the PRISM climate model, which provides estimates of mean monthly and yearly temperature and precipitation, and mean minimum and maximum monthly temperatures.

Field Planting

To initiate the study, seeds should be sown in greenhouse conditions (without stratification) using a loose, well- drained soil mixture that has been amended with a small percentage of soil from Mt. Hood Meadows. After eight weeks, grass plugs can be transplanted to a field plots using a randomized complete block design with four replications of six-seedling family plots. Spacing between plants can be as little as 0.1 meters, and a two plant border should be placed along all margins, as shown below. If

eight populations total are examined (six from Hood, two from Jefferson), this will result in the screening of (8 pops X 4 families per pop=) 32 families, with each family evaluated in four replicates with six seeds per rep (24 seeds per family). Assuming a 0.1 meter spacing, two 4' x 8' raised beds will be required. Weeds will need to be controlled with bi-weekly thinning, and supplemental watering will be necessary during the dry season. The test will need to be maintained and measured for three growing seasons.

B	B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B	B	B	B	B	B
B	B	1	1	1	4	4	4	2	2	2	B	B
B	B	1	1	1	4	4	4	2	2	2	B	B
B	B	3	3	3	7	7	7	5	5	5	B	B
B	B	3	3	3	7	7	7	5	5	5	B	B
B	B	8	8	8	6	6	6	9	9	9	B	B
B	B	8	8	8	6	6	6	9	9	9	B	B
B	B	10	10	10	e	t	c	.	.	.	B	B

B = border

Trait Measurement

A wide variety of traits involving growth, phenology, morphology, fecundity, and seed weight/germination can be recorded over a two- to three-year period. Growth traits, measured on all plants at the end of each of each season, may include leaf length, leaf width, mature plant height, culm height, inflorescence length, and "crown" diameter. Indices of plant form can be derived from ratios of these variables (e.g., total height/culm height, leaf length/leaf width). In years 2 and 3, additional traits may be assessed, such as leaf, awn, and inflorescence color, mature seed heads, and seed production (perhaps as classes, e.g., "no seed", "low seed", "high seed"). Other variables could include the mean (Julian) date of flower emergence, pollen dehiscence, and seed shatter. Germination data can also be obtained from seeds harvested in the field test at the end of the final growing season.

Statistical Analysis

Statistical analyses will be used to describe *C. breweri* variation patterns across the landscape and to identify the most important environmental factors determining that pattern. Analysis of variance (ANOVA) can be used to examine the organization of genetic variation, and to partition total variation into location and family-in-location variation according to nested random models. Data from all locations and samples can be used to estimate the average variance among families-in-locations ($\sigma^2_{F/L}$). Traits

should be omitted from ANOVA analysis if they have a highly skewed distribution that cannot be improved by transformation, or if location variance (σ^2_L) is non-significant when tested against the mean square for families-in-locations ($\sigma^2_{F/L}$). If correlation between two traits is high ($r > 0.80$), traits with the lower $\sigma^2_L/\sigma^2_L + \sigma^2_{F/L}$ should be deleted.

Principal component analysis (PCA) can be used to reduce the remaining retained traits into a smaller set of uncorrelated components to facilitate analyses and interpretation of results. Cluster analysis of principal component scores can be used to look at ecotypic structure and group seed source locations by their relative genetic similarity. Discriminant analysis can also be used to determine which physiographic and climatic variables best account for differences among the seed source groups. All remaining qualitative descriptor variables, such as ecoregion, seed zone, soil type can be evaluated with Chi-square analysis of class frequency tables.

Status of the Common Garden Study as of December 2006:

Calamagrostis Common Garden Study Activities to Date
By David Doede, Region 6 Geneticist

Seed was collected during 2004 and 2005 from Mt. Jefferson Wilderness on Willamette NF, Oregon (21 families- "WIL" families collectively), Deadfall Lake on Shasta-Trinity NF, California (11 families- "CA" families collectively) and Mt Hood on Mt. Hood NF, Oregon (21 families- "MTH" collectively). Species identification is difficult in the field. Of the California collections, only 2 were the correct species. There were 4 misidentified families in the Mount Hood collection, but all the Willamette families were correctly identified.

Seed amount and maturity was quite variable. The WIL seed was all mature, seed/family averaged 16 (5 – 34). Several families from the MTH had already shed the seed and some were immature (average/family =16 range 0-35). CA families were mostly immature (and not CABR).

Seed was sown into individual containers at the FSL Genetics lab in late May 2005 (with the help of Rich Cronn and Mat Horning), and germination started in early June. Germination was so spotty and often weak that the experimental design was modified to have 1 bed at Mt Hood Meadows with 8 very unbalanced replications of single plot families. There were 39 families planted (WIL – 20, MTH – 15, CA – 4), reps per family averaged 6.

First Year survival is the only trait observed to date. Overall survival was 38 per cent. Average family survival for WIL families (CB...) was .3645; for MTH families was .374, and for CA families was .2575. However, there are still 11 families with 4 or more individuals alive (6 from Jefferson, 5 from MTH).

APPENDIX E: MONITORING FORMS *CALAMAGROSTIS BREWERI* TRANSECTS

Calamagrostis	***breweri Data***	***Collection***	***Form***			
District/Forest:		**Location:**			**Date:**	
					UTM Zone 10	NAD 83
Surveyor(s):			**Transect #**		**E:**	**N:**
Section #	% CABR cover	# stems flowering	% ramets flowering (est.)	% Total cover	Ht./Wth. (cm) of tallest culm	Ht./Wth.(cm) of shortest culm
1 L						
1 R						
2 L						
2 R						
3 L						
3 R						
4 L						
4 R						
5 L						
5 R						
1	2	3	4	5		

L

R

Diagram: Place X where CABR clumps occur

CABR Transect Monitoring Form Page 2

Transect Information:				Associated species	% Cover
Disturbance (circle one each)	High	Medium	Low		
Lakeshore	User Trail	System Trail	Other		
Plant Communities (circle one)	Sedge = predominantly Carex nigricans	Herb = predominantly Aster alpigenus, & other herbs	Shrub = predominantly Heath family shrubs		
Notes (on recent disturbance, etc.):					