Festuca roemeri Common Garden Study

A Cooperative Project of:
Native Seed Network
Bureau of Land Management
Eugene, Medford, Roseburg, and Salem Districts
Natural Resources Conservation Service, Corvallis Plant Materials Center

Progress Report

September 2004

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EXECUTIVE SUMMARY
&
KEY ACCOMPLISHMENTS

The *Festuca roemeri* common garden study investigates the genetic variability of Roemer's Fescue across its geographic range. The results of this study will be used to define seed transfer zones.

Seed from wild populations of *Festuca roemeri* was hand collected during 2001 and 2002. This seed was grown into plugs and planted in a common garden at the USDA NRCS Plant Materials Center, Corvallis, Oregon. Genetic material from 47 populations across the naturally occurring range is included in this study. There are 14 populations from Washington, 30 populations from Oregon, and 3 from California.

The 2004 growing season was the first full growing season for the plants in the common garden. Plants began to flower as early as March and others continued flowering into June. The phenological status of each plant was recorded at weekly intervals throughout the growing season. Crown width, culm length, and culm abundance were also recorded.

The following traits have been recorded to date:

- emergence date
- germination rate
- albinism
- plant height (10 weeks)
- plant width (10 weeks)
- plant height (29 weeks)
- plant width (29 weeks)
- leaf color
- rust infection
- phenological status (weekly, March – July)
- culm height (74 weeks)
- crown width (74 weeks)
- leaf abundance
- culm abundance

BACKGROUND

The Common Garden Study
In 2001, Native Seed Network (NSN), the U.S. Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS) and the Oregon Bureau of Land Management (BLM) combined forces to establish a common garden study of *Festuca roemeri*. Seed from regional populations has been planted into a single environment at the Corvallis Plant Materials Center. Mature plants will be compared for morphologic traits, phenology, survival, and yield in this common environment. The goals of this study are to delineate the boundaries for transferring seed between source locations and project out-planting sites, and to provide initial seed to growers for commercial production.

Key Component of Grasslands
As a dominant matrix species of native grassland ecosystems, *Festuca roemeri* is highly desirable for restoration, rehabilitation and revegetation projects west of the Cascades and Sierra Nevada mountain ranges. This deep-rooted perennial stress-tolerater (*sensu* Grime 1977) has significant erosion control properties and xeriscape capacity.

The Problems Addressed by this Study
Currently there is little commercial *Festuca roemeri* seed available in the marketplace. Suppliers are hesitant to grow this grass because restoration workers do not agree on the appropriate geographic boundaries of seed transfer zones.

The Importance of *Festuca roemeri*
The beautiful bunchgrass *Festuca roemeri* (Roemer's fescue) is a community dominant in the gravel outwash prairies of northwest Washington, grasslands of southern British Columbia and the Willamette Valley, coastal grasslands of Puget Sound, and the serpentine and pine savannas of southwest Oregon and northwest California. Before European settlement, Roemer's fescue grew in large interconnected populations North from British Columbia, throughout western Washington, Oregon and Northern California. Populations south of Douglas County, Oregon have recently been described as a distinct subtaxon, Klamath Roemer's fescue, *Festuca roemeri* var. *klamathensis* (Wilson 1999). Our study focuses on northern Roemer's Fescue because this taxon has the greatest restoration potential and cultivation demand in Oregon and Washington.

Taxonomic Difficulties
Festuca roemeri has been beset by identification difficulties and taxonomic confusion. Initially, populations in Washington and northwest Oregon had been misunderstood as *Festuca idahoensis* Elmer populations. Roemer's fescue was first described as a variety of *F. idahoensis (*Pavlick 1983). Most commonly, Roemer's fescue is confused with Red fescue (*Festuca rubra* L.) Red fescue is

a morphologically similar but phylogenetically distinct grass. Therefore, *Festuca rubra* was long accepted as the dominant native grass of upland grasslands of Oregon and Washington (Franklin & Dyrness 1973).

The taxonomic difficulties surrounding the fine-leaved fescues of the Western Valleys are extraordinary. The conspecific grasses of southwest Oregon and northwest California have been variously identified as *F. idahoensis* Elmer, *F. ovina* L., *F. idahoensis* X *F. occidentalis* Hook. hybrids, *F. idahoensis* var. *oregona* (Hack.) C. L. Hitchc., and often *F. rubra* L. Many authors simply reported *Festuca* sp. (Atset unpubl. data, Copeland 1978, Frenkel & Kiilsgaard 1984, herbarium specimens). The recognition of *Festuca roemeri* as a taxonomically separate entity occurred first when Pavlick (1983) described it as a variety of *F. idahoensis,* and 2 years later its status was elevated to that of a distinct species (Alexeev 1985). *Festuca roemeri* is now described as consisting of two subtaxa: the true species *F. roemeri* var. *roemeri* to the north of Douglas County, Oregon, and the variety *klamathensis* to the south (Wilson 1999).

Phenotypic variation in the common garden.

Distinction Between Varieties of *Festuca roemeri*

Northern Roemer's Fescue (*F. roemeri* var. *roemeri*) has few, short hairs on the inner (adaxial) leaf surface and has a characteristic pattern of malate dehydrogenase (MDH) isozymes. Its range extends from British Columbia through western Washington and northwest Oregon south to the Douglas/Jackson County line (2002 unpubl. report to Bureau of Land Management Roseburg District) and south along the coast as far as San Francisco. Klamath Roemer's Fescue (*F. roemeri* var. *klamathensis* B. L. Wilson ined.) grows in southwestern Oregon and northwestern California, between the ranges of *F. roemeri* var. *roemeri* and *F. idahoensis,* except along the coastline where it is absent. Its many long hairs on the inner leaf surface and MDH isozyme pattern resembled *F. idahoensis,* but the phenotypic plasticity of its leaf shape resembled *F. roemeri* var. *roemeri.* Both varieties occur on serpentine as well as non-serpentine substrates. Our current study concentrates on northern *F. roemeri* var*. roemeri,* however, four populations of *F. roemeri* var. *klamathensis* are included for balance in the experimental design.

Once *F. roemeri* could be named and identified, its importance in native plant communities was quickly recognized (Wilson 1997). *Festuca roemeri* var. *roemeri* population groups are united by similar habitats and/or geographic location. Included in this study are populations from near Puget Sound, Olympia, the southern Willamette Valley, high elevation sites in the Coast Range, the foothills of the Cascade Range, and coastal sites (appendix A). With increasing knowledge about the taxonomy and range of *Festuca roemeri,* potential barriers to appropriate seed transfer became apparent. It is unknown whether the populations within these groups are genetically uniform or not, or whether the groups differ from each other genetically. This study is designed to address those questions.

Common garden, Summer 2004.

The *Festuca roemeri* Common Garden Study

The USDA's Plant Material Center in Corvallis, Oregon, was chosen as the site for the *Festuca roemeri* common garden. This site is located within the approximate center of a cluster of small remnant populations. Also, the issue of *F. roemeri* seed transfer is more critical in Oregon than in northwestern Washington. In Washington, the relatively large remnant prairies provide potentially adequate sources of local seed. In Oregon, prairie remnants are small and more likely to suffer from inbreeding depression. Also, *F. roemeri* often grows in mixed populations with introduced *F. rubra,* making it difficult to collect pure seed (Wilson 1997). Therefore, the demand for *F. roemeri* seed in Oregon could be filled by transferring seed from northwestern Washington more easily than the demand for seed in Washington could be filled with seed from Oregon.

METHODS

Seed Collection

Festuca roemeri seed was collected from 54 populations during 2001 and 2002. Seed collection was extended over a second seed season because 2001 was a drought year and many *F. roemeri* populations set little or no seed. Seed from 47 populations were used in the study. Because *Festuca roemeri* is easily confused with *F. rubra,* sample identification was checked by cutting leaf cross sections from the central third of a leaf from at least one of every five families collected, plus other samples which deviated from expected *F. roemeri* morphology. Leaf cross sections were drawn freehand and stored as a record of identification. Leaves will be stored until the end of the study.

Seed Sorting

Lemmas with filled seed were sorted from empty lemmas by hand using a light box. Lemmas were considered to contain filled seed if the seeds were opaque and stiff. Most filled seeds were also somewhat plump.

Samples from the Drano Lake, Duncan Spring, Edgewood-Weed Road, Glacial Heritage Park, San Bruno Mountain, and Skinner Butte populations became severely infested with the fungus *Aspergillus.* One week before planting (Dec. 8 & 9), these seeds were soaked in 1.5% sodium hypochlorite solution for 20 [to 50] minutes, then rinsed with distilled water and air dried. (200 ml 6% sodium hypochlorite solution (bleach) + 600 ml H20.)

Sowing

Seeds from 47 of the 54 *Festuca roemeri* populations sampled were sufficiently mature for inclusion in the study. Eight families per population were used (except where fewer were available, such as Abiqua Road, Memaloose Park, and Glacial Heritage Park). The study design included 8 individuals for each family. When sufficient seed was available, we planted three seeds in each of twelve tube containers for each family. When

Festuca roemeri seedlings after 10 weeks.

fewer than 36 seeds were available for a family, the number of seeds/container was adjusted downward, to a minimum of 1 seed in each of eight containers. A total of 4534 containers were sown with 12889 seeds.

Seeds were planted December 16 and 17, 2002 at the USDA-NRCS Corvallis Plant Materials Center. Flats were watered Dec. 17 and stored at 3°C in the dark until January 6, 2003, when they were placed in the greenhouse. The greenhouse was set with a 14 hour day-length. Daytime temperatures are 21°C (70°F) and nighttime temperatures are 18°C (65°F).

Germination & Early Growth

The greenhouse was checked daily for germination. Emergence date was recorded for each seedling. This work required inspecting all 4534 containers for newly-emerged cotyledons every day over several weeks. Emergence peaked on January 10th, four days after flats were brought into the greenhouse (Figure 1).

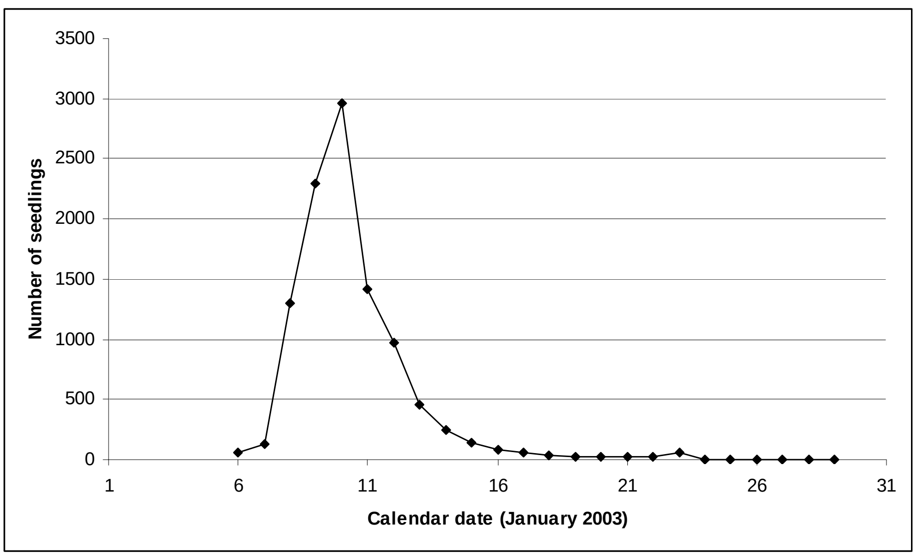

Figure 1. Seedling emergence

Albino seedlings were noted and recorded. Rate of albinism may be an indicator of population health. Albinos indicate a lack of reproductive success and possibly negative consequences of inbreeding. Rates of albinism varied widely between populations. Table 1 displays summarized emergence and albino data for ecological groupings of populations in the common garden study.

Table 1. Seed data organized by ecological group.

eco_group	planted	emerged	(%)	albino	(%)
coastal	1590	1224	(77.0)	14	(1.1)
gorge	367	233	(63.5)	0	(0)
high	1152	923	(80.1)	15	(1.6)
idahoensis?	288	201	(69.8)	11	(5.5)
inland	855	711	(83.2)	11	(1.5)
Olympia	2436	1916	(78.7)	34	(1.8)
Puget Sound	824	562	(68.2)	10	(1.8)
roemeri south	576	353	(61.3)	13	(3.7)
Willamette Valley	4765	3024	(63.5)	91	(3.0)

After ten weeks in the greenhouse, plants were moved to a shade house for several weeks to acclimatize. Before out-planting to the field, early growth measurements were taken. The leaf length was recorded (figure 2), and the width of the young plants was estimated categorically.

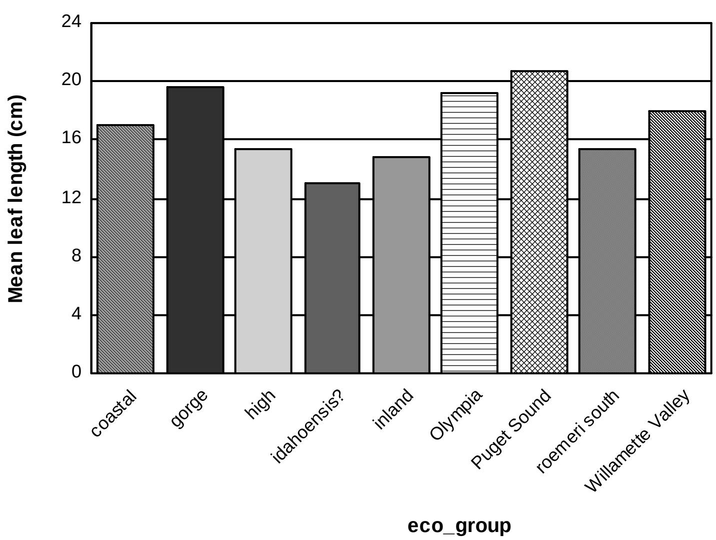

Figure 2. Leaf length before out-planting, by ecological group.

Field Planting

Prior to planting as the common garden, substantial effort and cost was incurred in field preparation. Plugs of *Festuca roemeri* were planted into a fallow field. A standard regimen of herbicide application was implemented to eliminate the existing seed bank. The field was then covered with three inches of bark mulch to aid in weed suppression. Slow-release fertilizer (Osmocote) was measured into each hole prior to planting each *F. roemeri* plug. Planting occurred over five days from May 8 to May 12, 2003. In total, 3009 plugs were planted into the common garden. Of these, 2767 are plants under study and 242 were planted as a border row to buffer against edge effects. The field was irrigated approximately once each month to help the plants establish during the first summer. Fungicide was applied periodically to prevent rust infection from severely inhibiting plant growth.

Field Measurements

Plants in the common garden were evaluated between July 28th and August 1st, 2003. In order to measure plant growth, the leaf length and crown diameter were measured. Plants were rated for the color of their foliage, which ranged between yellow-green and deep blue. Despite the application of fungicide, some plants showed signs of rust infection (figure 3, table 2). These were noted, as well as plants with senescent foliage, indicating dormancy (figure 4, table 2). Record was made of those plants that did not survive past this period.

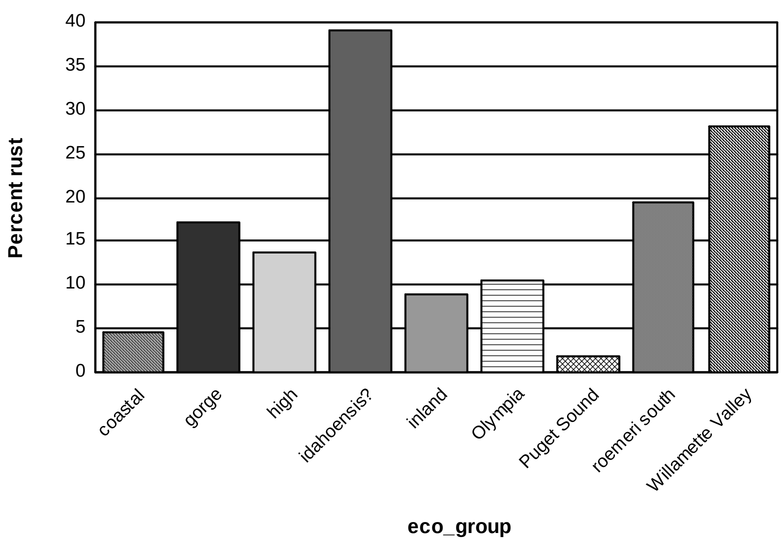

Figure 3. Rust infection rate among ecological groups.

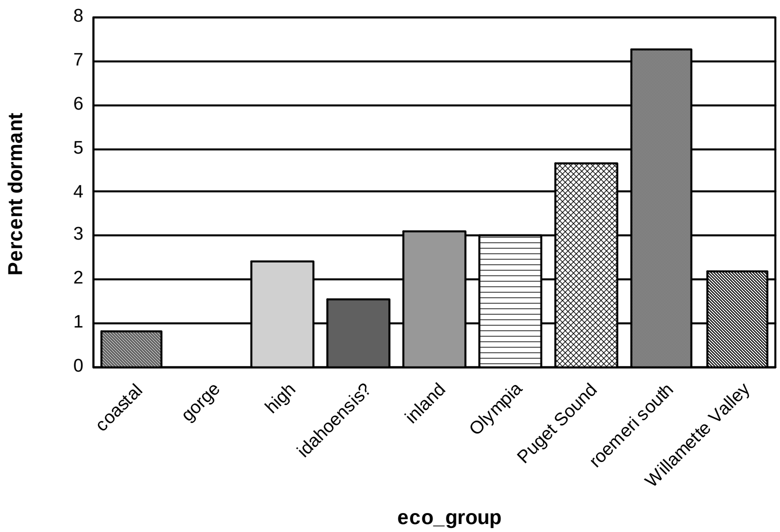

Figure 4. Dormancy rates among ecological groups.

Table 2. Rust infection and dormancy by ecological group.

eco_group	plants	rust	(%)	dormant	(%)
coastal	363	17	(4.7)	3	(0.8)
gorge	70	12	(17.1)	0	(0)
high	248	34	(13.7)	6	(2.4)
idahoensis?	64	25	(39.1)	1	(1.6)
inland	192	17	(8.9)	6	(3.1)
Olympia	562	59	(10.5)	17	(3.0)
Puget Sound	172	3	(1.7)	8	(4.7)
roemeri south	124	24	(19.4)	9	(7.3)
Willamette Valley	964	272	(28.2)	21	(2.2)

INTERIM UPDATE: PROGRESS SINCE NOVEMBER, 2003

2004 has been a busy year for data collection. Key data fall into two categories: phenology and morphology. Although some plants died over the winter, most plants were well established and grew vigorously throughout the spring. The variation in growth was impressive. By mid-March, some plants were only beginning to emerge from dormancy, while others were aggressively bolting, intent on reproduction. Preliminary analyses suggest that the earliest-blooming specimens are from the Klamath region.

As the growing season progressed, the difference between individual plants was striking. In addition to the variation in phenological response, morphology was also highly variable. The spectrum of plant shapes and colors suggests that there is significant genetic variation in this species. The statistical significance of these observed differences will be determined once the data analysis is complete.

An 'early bloomer' in the garden, March 15, 2004.

Phenological Data

From March to July, 2004, all plants were evaluated on a weekly basis for their stage of growth. Each plant was scored according to the scale in table 3. The sampling schedule is presented in table 4. In August, after plants had reached seed maturity, sampling frequency was reduced to every two weeks. Biweekly sampling will continue into the fall to monitor plant dormancy.

Morphological Data

In June plants were measured for their size and scored for their production of leaves and culms. The width of the crown was measured to the nearest centimeter, as was the length of the longest (tallest) culm. Early June was selected because plant growth was essentially complete for the season, and culms had attained their natural maximum length. Estimates of leaf and culm abundance were also recorded at this time. These were relative measures, scored on a scale of one to ten.

Table 3. Stages of phenological growth.

Score	Stage
0.	dormant
1.	vegetative growth
2.	boot stage- thickened culms visible
3.	elongation (jointing) of culms
4.	first emergence of inflorescence
5.	first anthesis
6.	50% anthesis
7.	milk stage (seeds)
8.	soft dough (seeds)
9.	seeds mature
10.	dormant

Table 4. Phenology sampling dates (2004).

March 9
March 15
March 23
March 30
April 6
April 13
April 20
April 27
May 4
May 11
May 18
May 25
June 1
June 8
June 15
June 22
June 29
July 6
July 13
July 20
July 27
August 3
August 17
August 31

Field Day

On June 26, 2004 NSN and the NRCS hosted a field trip to common garden site at the Corvallis Plant Materials Center. The event was attended by representatives from local open space committees, seed industry and farms, the Native Plant Society of Oregon, and other interested parties. In addition to presentations and a tour of the garden, we enjoyed discussions about restoration, seed production, and the future of our natural resources. We will host another field day in June 2005.

Additonal Steps Taken

From June 3 until July 20 (typically every Monday, Wednesday, and Friday), a team of workers identified plants with mature seed. The seed harvest was very labor intensive and time-consuming. There is a narrow window in which the seed is mature enough to harvest but not yet so ripe that it shatters and is lost on the ground. Having such a diverse planting as the common garden required frequent monitoring and harvesting on a plant-by-plant basis over a seven week period.

Seed collection, June 2004.

Seed from each plant was harvested and placed in labeled paper bags. These bags were stored in the greenhouse at the Plant Materials Center for several days until the seed moisture was low enough to ensure safe preservation. These bags of seed are presently being de-randomized (from their random field locations back into logical groupings, i.e. by family and population).

Collected seed will provide important data for describing the genecology of *Festuca roemeri*. Lemma and awn length, for example, have been identified as two morphological traits valuable for comparisons of fescues. Ultimately, seed yield will be determined. Seed will be processed and counted or weighed to determine variability between families and among populations. Yield data not only helps us understand differences between populations, but also will be useful information in planning for production of *Festuca roemeri* seed on a commercial scale.

Bags of seed drying in the greenhouse.

Future Plans

The flower and seed analyses have been initiated but are not complete. The seed heads have been harvested from the common garden but need further processing before useful data is obtained. Unlike the harvesting, where the schedule was dictated by the weather, seed processing can proceed in a laboratory setting at a time and pace set by the investigators.

The next important step is to undertake an anatomical study of the *Festuca roemeri* plants in the common garden. Leaf anatomy has proven to be very important in the taxonomy of the genus *Festuca* (Aiken & Consaul 1995). An anatomical study would greatly enhance our understanding of the genetic variability within Roemer's Fescue, increasing confidence in the seed transfer zones when they are described. A proposal for this work, entitled *Analysis of Roemer's Fescue (*Festuca roemeri*) leaf anatomy for common garden and seed zone study*, was submitted in May 2004 (see appendix B).

This large scope project has received considerable investment of time, energy, and money. We would like to thank the Bureau of Land Management for their continued support of the Roemer's Fescue Common Garden Study. In addition, we owe a debt of gratitude to the Corvallis Plant Materials Center for their donation of space, volunteer labor and expert recommendations. We continue to look forward to the day when our landscapes are once again dominated by the beautiful Roemer's Fescue.

Restored prairie? *Festuca roemeri* in the common garden, June 2004.

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Appendix A

Group	*Population*	*County*	*Number of plants in garden*
coastal			
	Cape Perpetua	Lincoln	64
	Cummins Creek Trail	Lincoln	64
	Lodgepole Meadow	Curry	62
	Mt. Tamalpais	Marin	64
	Pyramid Rock	Curry	45
	San Bruno Mt.	San Mateo	64
gorge			
	Drano Lake	Skamamia	64
	Memaloose Park	Hood River	6
high			
	Blue Mt. near Deer Park	Clallam	64
	Fairview Peak	Lane	64
	Hurricane Ridge	Clallam	56
	Mary's Peak	Benton	64
idahoensis?			
	Duncan Spring	Klamath	64
inland			
	Edgewood-Weed Road	Siskiyou	64
	Hukill Hollow	Jackson	64
	Silver Fork Elliot Cr.	Jackson	64
Olympia			
	Glacial Heritage Preserve	Thurston	55
	Johnston Prairie	Thurston	64
	Mima Mounds	Thurston	64
	Mortar Pt. 3	Thurston	64
	Rocky Prairie N.A.P.	Thurston	64
	Scatter Creek	Thurston	64

Group	***Population***	***County***	***Number of plants in garden***
	Thirteenth Division Prairie	Pierce	61
	Upper Weir Prairie	Thurston	64
	Yelm	Thurston	62
Puget Sound			
	Fidalgo Island; Ravine Trail	Skagit	52
	Smith Prairie, Whidbey Island	Island	64
	Yellow Island	San Juan	56
roemeri south			
	Ace Williams Mt.	Douglas	64
	Cobleigh Road	Jackson	60
Willamette Valley			
	Abiqua Road	Marion	40
	Bald Hill southeast	Benton	64
	Bald Hill west	Benton	64
	Baskett Butte	Polk	64
	Beazell (King's Valley)	Benton	64
	Fire Knob	Marion	32
	Horse Rock Ridge	Linn	64
	Kingston Prairie	Linn	52
	Kloster Mountain	Lane	64
	Morton's property	Benton	19
	Novick property	Lane	59
	Open Spaces Park	Benton	61
	Rock Hill	Lane	64
	Row Point, Dorena Reservoir	Lane	64
	Spencer's Butte	Lane	64
	Table Rock Wilderness	Clackamas	64
	Weiss Road ridgeline	Lane	61

Appendix B

PROPOSAL AND STATEMENT OF WORK
COST-SHARE PROJECT

Native Seed Network
2005

Eugene, Medford, Roseburg, and Salem Districts
Bureau of Land Management

Title: Analysis of Roemer's Fescue (*Festuca roemeri*) leaf anatomy for common garden and seed zone study

Background:

2005 is the fifth year of the *Festuca roemeri* Common Garden Study. We now have a beautiful half-acre plot with approximately 3000 mature *Festuca roemeri* plants. This living collection contains genetic material from throughout the full range of the species, from San Francisco Bay to the San Juan Islands. We plan to exploit this unique resource for the leaf anatomy study.

Our current research has shown that leaf anatomical traits are among the most important for distinguishing *Festuca roermeri* ecotypes. Fescues respond to environmental variation with both phenotypic and genetic variation in their leaves. In the common garden study, the genetic component of this variation can be assessed. Detecting and measuring these traits is a time consuming process, which we believe is worthwhile because it provides an important set of data for understand *F. roemeri* ecotypes and seed transfer zones.

Review of work completed to date:

- Fall 2003: Leaf samples were taken for anatomical study from all surviving plants in the common garden.

Proposal and Work plans for 2005:
Fall and Winter 2004

- Final selection of leaves for anatomical study will be made from the samples at hand. (3 samples/population, no more than one per family)
- Photomicroscopy of leaf cross sections

Spring and Summer 2005

- Measurement of selected features on leaf cross section photographs
- Data entry
- Data analysis

Summer and Fall 2006

- Write results of leaf anatomy study for publication

Benefits

Through their leaves, plants interact with sunlight, the atmosphere, transpired water, wind, herbivores, and fungal pathogens. Therefore, the practical question of where to transfer native seeds in restoration projects is, in part, a question about the patterning of leaf anatomy. Previous research has shown that variation in leaf anatomy may be the most important morphological trait distinguishing *Festuca roemeri* ecotypes.

The study of leaf anatomy of *Festuca roemeri* using plants from the large common garden study will contribute greatly to assessment of seed transfer zones for this species.

Projects that require genetically appropriate native plants include recreational developments, roadside revegetation, road decommissioning, ecosystem restoration, wildlife enhancement projects, fire recovery, restoration after invasive species removal and other mitigation projects. Demand for native seed will continue to increase. This study will provide structure to an emerging seed industry, resulting in improved efficiency and reduced seed costs.

Deliverables

- October 2005 Interim report, documenting progress to date and key tasks accomplished in the study.
- October 2006 Final Report of results of the *Festuca roemeri* leaf anatomy study including key leaf morphology information pertinent to establishing seed zones for this species

Budget -- BLM Contribution:

Photomicroscopy (equipment)	$ 4000
Photomicroscopy (labor)	$ 3000
Measurement and data entry	$ 2000
Analysis	$ 3500
Report writing	$ 3500
Total BLM Contribution	$16000

Schedule of Payment

October 2005	$ 8000
October 2006	$ 8000

We will match these costs (1:1) with Principal Investigator salary, administrative support, in-kind services, and/or volunteer support. Values include 15% overhead.