

Polycross populations of the native grass

# *Festuca roemerii*

as pre-varietal germplasm: their derivation, release, increase, and use

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## ABSTRACT

Results of a recent common-garden study provide evidence needed to delineate appropriate seed transfer zones for the native grass *Festuca roemerii* (Pavlick) E. B. Alexeev (Poaceae). That information has been used to develop pre-variety germplasm releases to provide ecologically and genetically appropriate seeds for habitat restoration, erosion control, and other revegetation projects in 5 regions of the Pacific Northwest, US. Seed sources for these composite populations were chosen to represent a broad base of genetic diversity found within each region, while using plants that overlap in flowering time, have average to high seed yield, and originate at similar elevations. The process of selecting appropriate seed sources and developing the germplasm releases is described here. Ongoing and future investigations are likely to include seed production technology, establishment methods, stand management, and adaptation to diverse sites and specific uses.

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## KEY WORDS

common-garden study, seed transfer zones, habitat restoration, erosion control, selected class release

## NOMENCLATURE

Plants: Barkworth and others (2007)

Fungi: ITIS(2008)

Upland prairie. Photo by Barbara L Wilson

## THE PLANT

*Festuca roemerii* (Pavlick) E. B. Alexeev (Poaceae) was once an important component of plant communities on sites as diverse as prairies, coastal headlands, and oak and pine savannas (Figure 1). It is found at elevations of 30 to 1830 m (100 to 6000 ft) from southern British Columbia to the San Francisco area of California, entirely west of the Cascade Range and Sierra Nevada (Wilson 1999). Large populations of *F. roemerii* survive on gravel outwash prairies in Thurston County, Washington, and in serpentine habitats in southwest Oregon and northwest California. Elsewhere, *F. roemerii* exists in small, isolated, remnant populations, most consisting of a few dozen to a few hundred individuals (Wilson, personal observation). *Festuca roemerii* tolerates moderately acid to slightly basic soils, including serpentine and other unusual soils, in full sun to partial shade. It grows best in well-drained, fine- to medium-textured soils. It is drought tolerant but generally grows in mesic rather than xeric sites.

*Festuca roemerii* is a C3 bunchgrass with narrow leaves, most of them clustered in a dense basal tuft (Figure 2). Leaves are light blue to green, and culms are 30 to 100 cm (12 to 40 in) tall, terminating in an open panicle. Plants are slow-growing, wind-pollinated, outcrossing perennials, rarely flowering before their second year. Individual plants have variable longevity, perhaps with the potential to survive for decades like the related *F. idahoensis* Elmer (Liston and others 2003).

This grass was recently described as *F. idahoensis* var. *roemerii* Pavlick (Pavlick 1983) and later treated as a species (Alexeev 1985). Inland populations of southwest Oregon and northern California differ from northern and

coastal populations in details of leaf anatomy and isozyme patterns (Wilson 1999) and have been recognized as a different subtaxon, *F. roemerii* var. *klamathensis* B. L. Wilson (Wilson 2007).

## THE PROBLEM

*Festuca roemerii* is valued for habitat restoration projects because it is a native, upland, community dominant. Its bunch grass habit minimizes competition between native *F. roemerii* and the native forbs also included in restoration plantings. Its modest stature and extensive root system that can hold soil make it desirable as a ground cover and for erosion control in vineyards, young orchards, and naturalized landscapes.

However, *F. roemerii* is underutilized in restoration plantings. One serious problem is that it often grows in mixed populations with *F. rubra* L., and the two species are easily mistaken for each other (Wilson 1997; Dunwiddie and Delvin 2006). Ensuring that wild-collected seeds are actually *F. roemerii* requires careful examination of each individual plant from which seeds are collected, or growing seeds in cultivation for at least one generation and removing those plants that are not *F. roemerii*. Therefore, it is more practical to obtain pure *F. roemerii* seeds from cultivated sources that have been checked repeatedly for identification.

Another problem is that appropriate distances for moving *F. roemerii* seeds are unknown. Using locally adapted seeds is desirable (McKay and others 2005), but many issues go into deciding how far it is genetically and ecologically appropriate to move plants (Rogers and Montalvo 2004). Morphological, isozyme, and physiological differences between northern and southern populations (Wilson 1999) suggest that populations of *F. roe-*

*merii* var. *klamathensis* should not be moved into the range of *F. roemerii* var. *roemerii*, and vice versa. Even moving plants more than a few miles within the Willamette Valley has been questioned, in part because the small remnant populations in that area differ from one another in color, height, and other traits (Wilson, personal observation).

## THE PROCESS

We are working to develop pre-varietal selected class releases of *F. roemerii* germplasm of known origin for habitat restoration and other uses. The pre-varietal germplasm approach was implemented by the Association of Official Seed Certifying Agencies (AOSCA) as an alternative to cultivated variety releases ("cultivars") as a means to provide third-party verification of the source, identity, and genetic purity of wild plants and seed collections (Young and others 2003). Such native material may be designated and certified as "source identified class," "selected class," or "tested class." The first category represents essentially wild, unevaluated germplasm of known origin, the second is material with the promise of desirable or different traits upon comparison with other seed sources, and the third is material that is progeny tested with proven, desirable, and heritable traits. The USDA Natural Resources Conservation Service has formulated a program of release that reflects these standards with additional testing and documentation requirements (USDA NRCS 2000). We choose to produce selected class pre-varietal releases because we anticipate that this process will lead to improved availability of diverse native *F. roemerii* germplasm of known origin for habitat restoration and other uses.

The seed sources used to produce each release were based in part on the



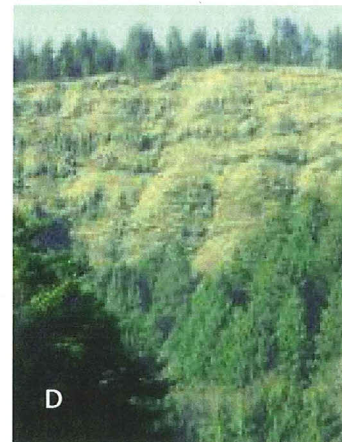
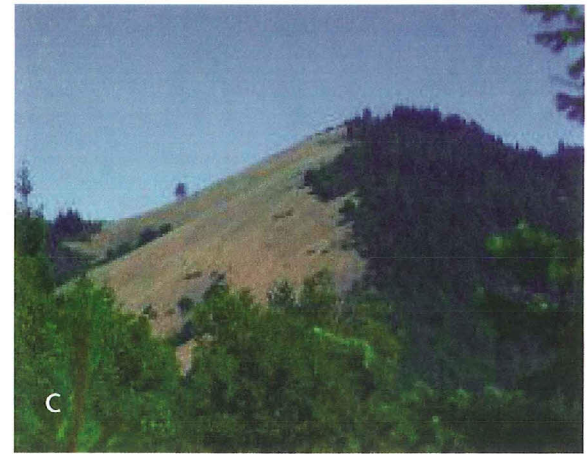
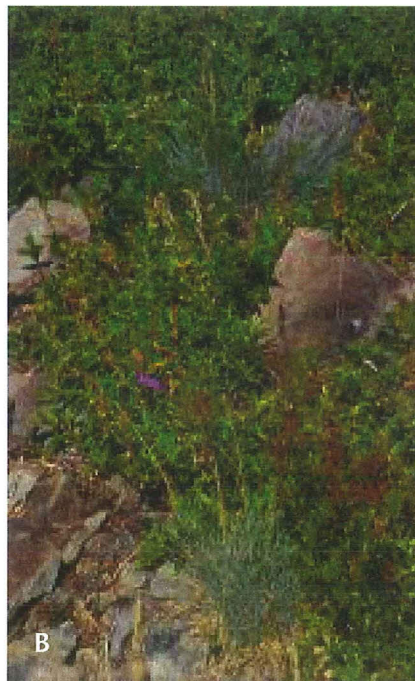
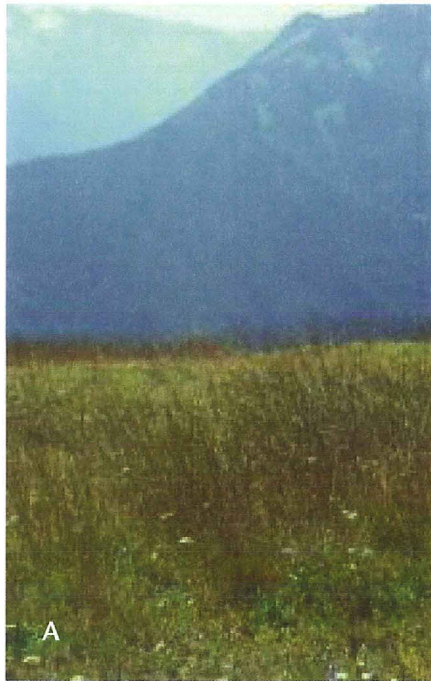


Figure 1. *Festuca roemerii* habitats: upland prairie (A), rocky mountain grassland (B), savanna along transition zone between xeric south slope and forested north slope (C), coastal headland (D). Photos by Barbara L. Wilson

results of a common-garden study (Wilson and others 2008). In that study, 43 *F. roemerii* populations from throughout its range were analyzed. Plants were highly variable in color, size, leaf width, fecundity, and other traits. Some individual populations were recognizable, but more general patterns were difficult to discern in the field (Figure 2). Numerous traits were measured in order to describe growth, morphology, rust occurrence, phenology, survival, and yield (Wilson and others 2008). Subsequent principal component analysis, along with elevation and Level III ecoregion delineations (Thorson and others 2003) helped identify clusters of populations with similar phenology and growth characteristics (Wilson and others 2008).

Based on that study (Wilson and others 2008), we feel justified in producing selected class germplasm releases in-

tended for particular ecological and geographic zones (Figure 3), corresponding to the Puget Lowlands, Willamette Valley, Coastal, and Siskiyou Level III ecoregions (Thorson and others 2003). The populations of the Puget Lowlands ecoregion (Thorson and others 2003) in western Washington were divided into a Puget Trough germ plasm corresponding to the South Puget Prairie and Cowlitz/Chehalis Foothills Level IV ecoregions, and a San Juan gennplasm corresponding to the San Juan and Olympic Rain Shadow Level IV ecoregions (Woods and others 2001). The Puget Lowlands populations were split, partly for reasons of biology (the San Juan populations are geographically isolated from the Puget Trough populations and differ slightly in the common garden) and partly because land managers on the islands expressed concerns

about moving seeds from the mainland into island populations.

Although the Willamette Valley populations were more genetically diverse than the Washington populations, the former were treated collectively as one seed zone for 2 reasons. First, the Willamette Valley cluster could not be subdivided into geographic or ecological groups. Second, multiple lines of evidence suggested that the small, isolated, remnant *F. roemerii* populations in the Willamette Valley ecoregion may have lowered fitness (Wilson and others 2008), perhaps due to a combination of inbreeding and genetic drift. Therefore, combining germ plasm from these populations may create a pre-variety release with improved fitness compared with the contributing parental populations.

The 2 Coastal populations were not strongly divergent in Principal Compo-



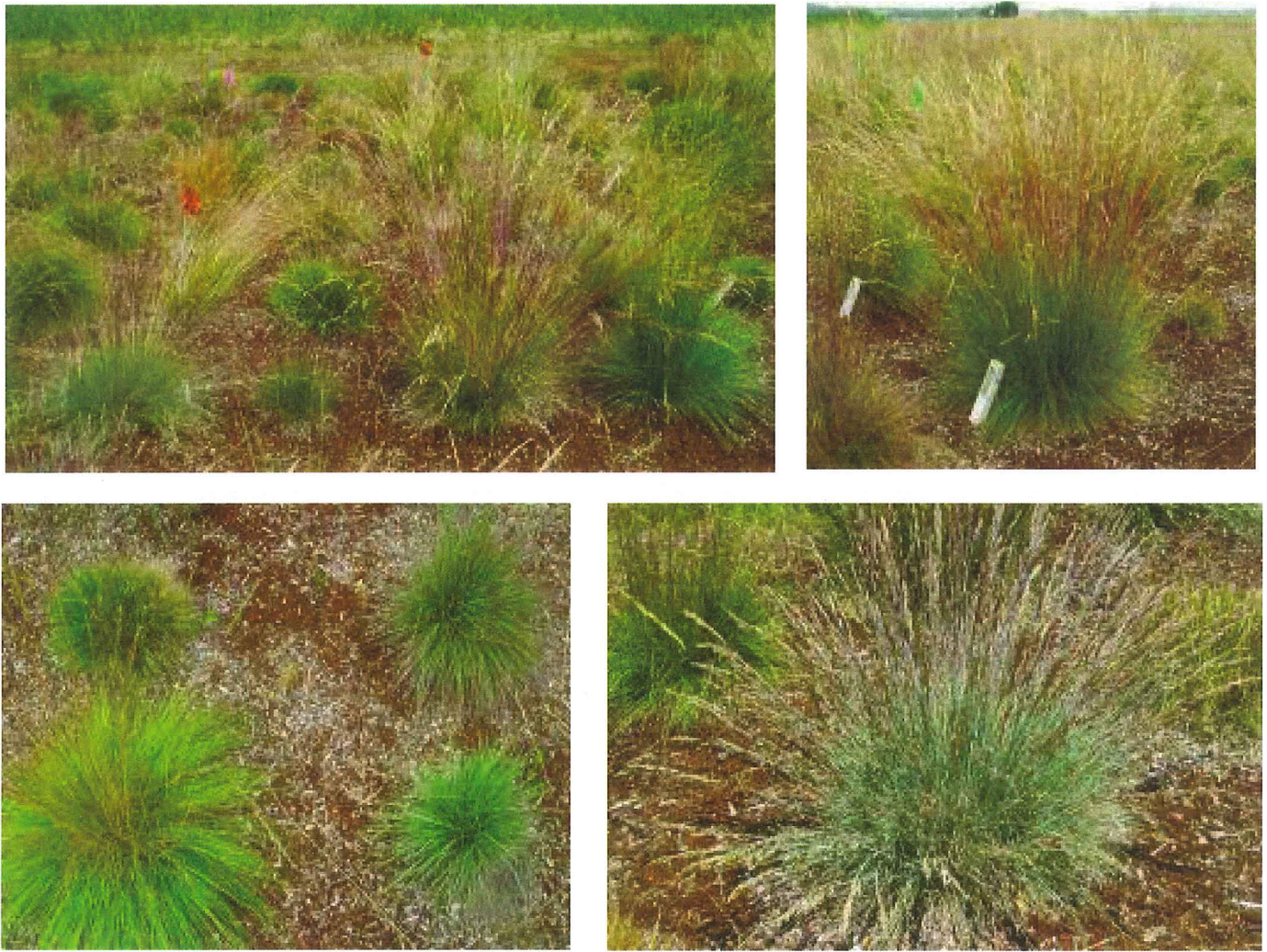


Figure 2. Variation in *Festuca roemerii* plants grown in the common garden. Photos by Dale C Darris

nents Analysis (Wilson and others 2008), but they were used to produce an additional pre-variety selected class release for 2 reasons. First, they were geographically isolated from other populations. Second, they had the highest average seed yield and one population had the highest survival rate after the floods of the 2005-2006 winter, indicating that they were well suited for cultivation and for commercial as well as habitat-restoration applications.

The high elevation populations widely scattered in both timing-related and growth-related traits and were disjunct geographically. Therefore, they do not justify a seed zone.

In creating the pre-variety germplasms, maximizing genetic diversity was a goal. Therefore, all tested populations originating within a seed transfer zone were used to produce the polycross populations unless there was a reason to exclude them. Two to nine populations were chosen to contribute to each polycross germplasm. For the Willamette Valley polycross, populations above 915 m (3000 ft) were omitted, as were those that had low seed yield. For the Puget Trough polycross, 2 populations were omitted, one due to permission difficulties and one because it did not flower in 2006. The few surviving plants in the tiny, low-yielding Yelm population grew in a

vacant lot surrounded by development, and they did not flower the year that seed collection was attempted. The Siskiyou polycross was supplemented with a geographically proximate additional collection near Fort Jones, California, to represent more fully this region's genetic diversity.

To produce plants of the selected populations, remaining G0 wild seeds collected in 2001-2002 for the common garden, or seeds newly collected in 2006, were sown in shallow plastic flats in 2006. In late August, seedlings were transplanted from the flats into conical-shaped plugs (115 ml [7 in<sup>3</sup>] Ray Leach Cone-tainers) and were maintained outdoors



until transplanted into isolated field locations between January and March 2007. The Willamette Valley, Puget Trough, San Juan, and Siskiyou regions were each represented by one isolated G1 crossing block. These 4 blocks are situated on 3 research farms owned by the Oregon State University Agricultural Experiment Station in the vicinity of Corvallis, Oregon, elevation 65 to 69 m (215 to 225 ft). The crossing blocks and initial and future G1 and G2 seed increase fields are being managed and harvested by the NRCS Corvallis Plant Materials Center.

Each crossing block functions as a polycross nursery (Figure 4) planted in a Latin square design. The blocks are isolated from each other by a distance greater than 274 m (900 ft), the minimum distance permitted for G1-G2 pre-varietal seed certification. Each plot consists of 3 to 9 plants of the same parent population, depending on the crossing block. Spacing is 15 cm (6 in) within plots and 61 cm (24 in) between rows and plots. Each plot is replicated by the number of populations included in each crossing block or by an exact multiple thereof.

Because relatively large amounts of seeds could be collected in 2006 from both Coastal populations, they were treated differently (Figure 5). To establish the G1 field of the Coastal germplasm, G0 seeds were collected from Cape Perpetua and Cummins Creek in July 2006 and sown directly into an isolated fallow field for seed increase during October 2006. Also, individuals from Coastal populations that survived in the common garden were transplanted to the field. Seeds from the same 2 sites were subsequently recollected in July 2007 and sown in October 2007 to expand the field to a total of 0.1 ha (0.25 ac). Row spacing was 30 cm (12 in).

Weeds in the G1 crossing blocks and increase field are controlled with a regimen of hand hoeing, tillage, or herbicides labeled for grass seed production. Stands are fertilized once each March with 56 to 84 kg/ha (50 to 75 lb/ac) of actual nitrogen (33N:0P:0K:12S). No summer irrigation water is applied when planting is completed in fall and winter. Quilt (azoxystrobin and propiconazole) fungicide was applied twice during the summer of 2007 for suppression of leaf rust (*Puccinia* spp. [Uredinales: Pucciniaceae]) and will be used again as needed.

#### PLANS FOR THE FUTURE

G1 seeds from the crossing blocks will be used for G2 agronomic seed increase. To further ensure random mating and to avoid poor representation of less productive populations in the pre-varietal releases, special methods will be applied to establish G2 seed increase fields of *F. roemerii*. First, seeds from each plot in the crossing blocks will be harvested separately and

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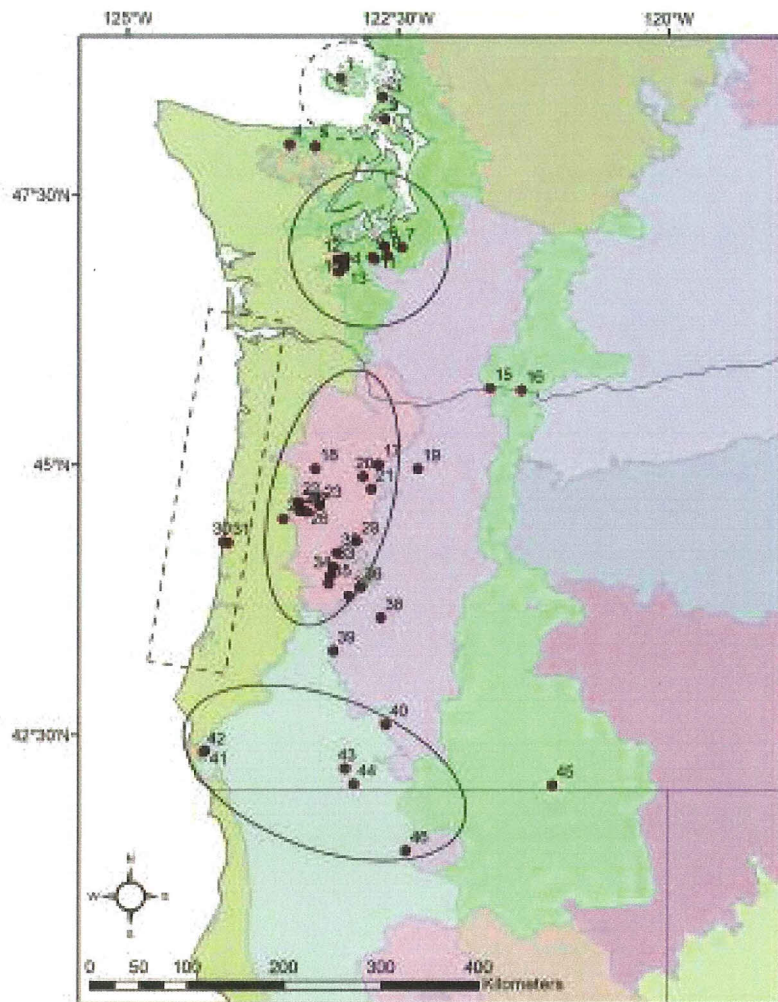


Figure 3. Geographic distribution of populations used to create selected-class pre-variety releases of *Festuca roemerii*. Yellow: San Juans. Blue: Puget Trough. Green: Willamette Valley. Brown circles: Coastal. Red triangles: Siskiyou.



Figure 4. Crossing block for Puget Trough pre-variety germplasm of *Festuca roemerii*, set up in a Latin square design to maximize cross pollination: 4 plant plots replicated 7 times, one plot per each row and each column. Photo by Dale C Darris

bulked by individual population. G1 seeds will then be used to grow a similar number of plugs of each parental population line. These half-sib descendents of each line will be transplanted into separate, adjacent bed rows that will constitute the G2 increase field. This way, bed rows of each line can be swathed at different times if maturity varies among populations and can be harvested with separate combine passes if necessary. With these precautions, a better representation of each line can be secured before the seeds are fully bulked and distributed to growers for commercial increase. Given the complexity and cost of this process for Gland G2 seeds, private producers will be allowed to grow the next generation using standard operating procedures for field-scale increase. Because of potential genetic shift or drift, commercial increase will be limited to one or two additional generations.

Certification of G1 through G3 (or G4) seed stocks will be performed by the Oregon Seed Certification Service. Finally, public releases will be made of the 5 cultivated lines (in this case selected class pre-variety germplasms) by cooperating agencies and organizations. Tentative names for the 5 germplasm releases are similar to the seed zones they represent: San Juan Islands, Puget Trough, Willamette Valley, Coast, and Siskiyou germplasms.

Once enough G2 seed stocks are on hand, and supporting documentation for the 5 selected class germplasm releases is finalized and approved, seeds will be made available to private growers for increase and marketing. Agencies and organizations participating in the release will include the USDA Natural Resources Conservation Service, the Institute for Applied Ecology, the USDI Bureau of Land Management, and the USDA Forest Service. We anticipate commercial availability of Coast

Germplasm by 2011 and San Juan Islands, Puget, Willamette Valley, and Siskiyou germplasms by 2013.

## DISCUSSION

The *F0 roemerii* common-garden study took 7 years from an initial year of seed collection (which failed due to poor weather) through analysis and writing. These years are only the first step, however, in the process of establishing selected class pre-variety germplasm releases through the NRCS Corvallis Plant Materials Center. Making appropriate crosses and then increasing the seeds of this perennial grass will take several more years. Fortunately, the process is already underway.

Each germplasm release is targeted for use within the same seed zone from which the parent material originated and for which it is adapted. Expanded geographic ranges and roles outside of restoration (for example, cover crop or low-maintenance turf) by one or more pre-varieties may be suggested after future evaluation and testing.

Concurrent with the germplasm releases of "*H0 roemerii*", attempts are under way to refine agronomic seed-increase methods, improve revegetation techniques, evaluate management practices for restored and utilitarian landscapes, and ascertain adaptation to different soils and other environmental variables. Among the initial efforts associated with this project are studies on seed dormancy, which showed faster and more uniform germination with a 14-d cool, moist stratification (Wilson and Kaye 2002) and the influence of simulated field burning on seed yield of *F. roemerii* under cultivation (NRCS unpublished data). Field burning is one of several methods used to manage stand recovery, reduce postharvest residue, and potentially improve seed yields of grasses. Tests are being conducted to determine its effectiveness with *F0 roemerii* (Figure 6). Most recently, the NRCS Corvallis Plant Materials Center and the Oregon State University Crop and Soil Science Department have begun partnering on experiments to determine the tolerance of native grasses to various herbicides used in grass seed production. The goal is to obtain 24C special local-needs labels so that select herbicides already approved for introduced species can be used on native species. One of several experiments planted during fall 2006 investigates the use of diuron for control of annual grassy weeds in a newly planted, carbon-banded field of *F0 roemerii* (Figure 7). Besides seed-production technology, future evaluations with this species are likely to include seeding rates, methods, and mixtures for revegetation and restoration; stand management; adaptation of populations to diverse sites; and suitability for cover in vineyards and young orchards or as low-maintenance turf.



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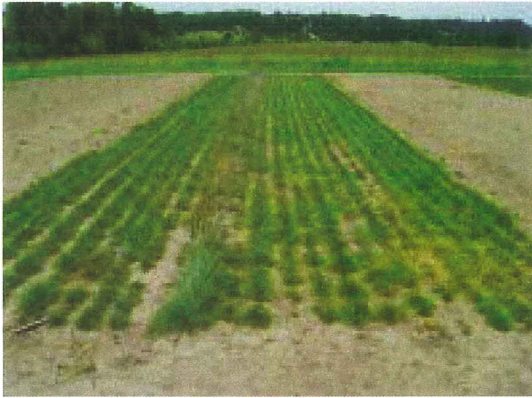


Figure 5. G1 seed-increase field for the Coastal pre-variety germplasm of *Festuca roemerii*. Note the row formed by survivors transplanted from the common- garden study. Photo by Dale C Darris



Figure 6. Test of field burning (simulated using a propane flamer) for management of post-harvest residue in *Festuca roemerii*, in cooperation with the Crop and Soil Science Department of Oregon State University. Photo by Amy Bartow



Figure 7. Diuron herbicide trial for the establishment of *Festuca roemerii* seed increase fields, in cooperation with the Crop and Soil Science Department of Oregon State University. Photo by Dale C Darris

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