Richard Robohm
Center for Urban Horticulture
University of Washington
3501 NE 41st Street
Seattle, Washington 98195

Survival and Growth of Planted *Festuca idahoensis* in Prairie Restoration Sites at Ft. Lewis, Washington.

Richard Robohm

Abstract

The researcher studied the growth of transplanted Idaho fescue (*Festuca idahoensis*), a native bunchgrass, at two disturbed grassland sites at Ft. Lewis in western Washington state.

At the Mortar Point 10 site, which lies within the Artillery Impact Zone on 91st Division Prairie, large earth-moving equipment churned the soil and denuded it of vegetation in 1994, creating a need for restoration. In April 1995, workers planted Idaho fescue plugs into three-meter-square plots in three different planting schemes: 1/4-meter on center, 1/2-meter on center, and 1/2-meter on center and interplanted with four different native forbs and graminoids. We applied mulch to half the plots in each planting scheme. Idaho fescue grew impressively in all plots, increasing average bunch diameter severalfold one year after planting. All surviving bunches flowered and produced seed in the year following planting. The three planting schemes showed no difference in growth or reproduction of Idaho fescue 15 months after planting. Mulching caused higher mortality of transplanted plugs, but growth and reproduction of surviving mulched plugs matched that of unmulched plugs. Mulch also promoted colonization of exotic species over natives.

Disturbance at the 13th Division Prairie site includes past livestock grazing, but direct human impacts now are minimal. A low-intensity grassfire burned over the site in March 1995. Dominance of Idaho fescue is challenged particularly by the non-native bentgrass, *Agrostis tenuis*, and by a variety of weedy forbs. Workers installed a factorial experiment with three treatments, herbicide, mulch, and irrigation, at 13th Division Prairie. We applied each of eight possible treatment combinations in five randomized blocks of eight 2-meter-square plots. In April 1995 we sprayed half of the 40 plots with a grass-specific herbicide tolerated by Idaho fescue. In May 1995 we planted Idaho fescue into existing vegetation, 1/2-meter on center, and mulched half of the plugs in these plots. We irrigated half the plots from mid-July through September 1995. In contrast to results at Mortar Point 10, mulch had a significant positive effect on plugs transplanted into existing vegetation at 13th Division Prairie. Overall mortality at this site was 19% at the end of the first growing season, compared with 7% at Mortar Point 10. Increases in basal diameter were quite modest for all treatments. Plots treated with herbicide showed significant positive effects on bunch diameter, native cover, and diversity.

Introduction

Native *Festuca idahoensis* Elmer (Idaho fescue) grasslands of the Puget Trough are rare and unique ecosystems in a region dominated overwhelmingly by coniferous forests (Franklin and Dyrness 1988; Kruckeberg 1991). Grassland ecosystems west of the Cascade crest are home to several regional endemic species, including rare plants such as *Aster curtus* Cronq. and *Castilleja levisecta* Greenm. (Wentworth 1994; Thomas and Carey 1996). Western Washington grasslands also are refuges for many plants and animals whose normal range lies east of the Cascade crest or south of the Columbia River. Species diversity is among the highest of any ecosystem in the state of Washington**.**

Road construction, urban development, military operations, and livestock grazing have diminished the extent and quality of this native grassland during the last century. Much that remains today has been disturbed and invaded by exotic species. In addition, since suppression of grassland fires by Euro-American settlers, otherwise intact grassland has been shrinking because of encroachment by woody species (Lang 1961; Giles 1970; Evans, Gilbert et al. 1975).

Application of restoration techniques that yield the greatest benefit for the resources invested will help preserve prairie landscapes and the biodiversity they embody. Evaluating methods of restoring Idaho fescue grassland will promote this goal by determining the most effective and efficient restoration techniques.

Experiments discussed here were designed to test various treatments and planting schemes using Idaho fescue and associated species. This paper will review the effects of these treatments and planting schemes on survival, leaf length, and bunch diameter of *Festuca idahoensis*.

The following hypotheses were among those tested:

- Applying mulch enhances establishment and growth of *Festuca idahoensis* plugs.
- Applying grass-specific herbicide to kill non-native grasses does not harm *Festuca idahoensis.*
- Summer irrigation of newly planted *Festuca idahoensis* plugs enhances survival and growth.

Methods and Materials

Mortar Point 10

Mortar Point 10 lies on the eastern edge of the Artillery Impact Area at Fort Lewis in Pierce County, Washington (47°01'N, 122°34'W), approximate elevation 97 meters. The 91st Division Prairie, one of the largest remaining native grasslands in western Washington, is largely contained within the Artillery Impact Area.

Trenches and berms were constructed for military purposes on a portion of Mortar Point 10 in 1994, disturbing many hectares of high-quality, Idaho fescue-dominated native grassland. These earthworks were filled in and graded by early 1995, leaving extensive areas of soil virtually devoid of above-ground vegetation. Soils consist of very gravelly sandy loam with many large cobbles, typical of the Spanaway soil series formed on glacial outwash plains in this region.

Thirty 3-meter by 3-meter square plots were laid out across a 13-meter-wide by 48-

meter-long band of bare ground, near the eastern edge of the disturbance. This band, whose long axis runs northeast-southwest, lies perpendicular to a slight topographic gradient with a high elevation near the northeastern end. Plots are two meters apart in three rows of ten plots each.

Ten plots each were planted as follows:

I. Idaho fescue plugs only, 0.5 meter on center.
II. Idaho fescue plugs, 0.5 meter on center, interplanted with four associated native species.
III. Idaho fescue plugs only, 0.25 meter on center.

Mulch was applied to five randomly selected plots in each planting scheme, providing five control and five treatment replicates for each.

13th Division Prairie

Study plots for a factorial experiment were located just south of South Creek in Area 15 at the eastern edge of 13th Division Prairie at Ft. Lewis (47°0'N, 122°26'W), elevation approximately 125 meters. This area, where a controlled burn was carried out in March 1995, contains a mix of native and exotic species, including the non-native *Agrostis capillaris* L. (colonial bentgrass). The rhizomatous bentgrass can have a pernicious effect on the character of the native bunchgrass ecosystem, replacing tufted plains with a more uniform turf. Unlike Mortar Point 10, study plots at this site were covered with existing vegetation.

Forty 2-meter by 2-meter plots were laid out in a randomized block design using five blocks of eight plots each. Idaho fescue plugs were planted, 0.5 meter on center, into existing vegetation in the 40 plots. Effects of three factors (grass-specific herbicide, mulch, and irrigation) were tested separately and in all possible combinations, with five replicates of each combination, including control plots.

Plant Material and Mulch

Seeds of Idaho fescue collected from Ft. Lewis prairies were germinated in flats and grown in a standard soil mix in Styrofoam dibble blocks in a greenhouse at the University of Washington's Center for Urban Horticulture. The dibble blocks (BC Products item #CFS 2A-211A) contain 240 elongate conical planting holes 2.3 centimeters (cm) in diameter at the top and 11.5 cm deep. After germination, seedlings were transplanted into dibble blocks in March and placed in an unheated hoop house with a translucent white polyethylene roof. Seedlings were watered regularly and fertilized with complete liquid fertilizer**.**

The four non-fescue species planted were *Aster curtus*, *Camassia quamash* (Pursh) Greene*, Carex inops* L. Bailey ssp. *inops*, and *Luzula campestris* (L.) DC. *Aster curtus* and *Camassia quamash* plants were previously salvaged from grassland sites in Pierce County, Washington, within 20 kilometers (km) of Mortar Point 10. Plants of the other two species were salvaged prior to planting from the edge of a gravel pit in Area 7S at Ft. Lewis, approximately 10 km north-northeast of Mortar Point 10. Salvaged plants were transplanted into 10-cm square plastic pots in standard soil mix and kept in a polyethylene-sheathed hoop house with the Idaho fescue seedlings. Forty plants of each species were planted.

Screened compost, a weed-free mixture of composted manure and sawdust, was used for mulch.

Herbicide Application - 13th Division Prairie

A selective, post-emergence systemic grass herbicide (Poast®, a cyclohexanedione known as sethoxydim, manufactured by BASF Corporation) was applied in combination with a non-phytotoxic oil concentrate to 20 plots at 13th Division Prairie. Treated plots were selected according to the randomized block design. Fine fescues are tolerant of this herbicide, which does not harm non-grass graminoids, other monocots, or dicots.

Poast® destroys the grass meristem by inhibiting biosynthesis of lipids in growing and dividing cells. Applied to foliage, Poast® is symplastically translocated with sugars from leaves to sites of metabolic activity in roots and shoots (Ross and Childs 1996)

Planting and Mulching

A total of 2,510 Idaho fescue plugs were planted in the 30 plots at Mortar Point 10 during April 1995. For plots interplanted with other native species, non-fescue plants were more or less evenly distributed throughout each plot, which contained 33 fescue plugs and 16 other plants, four of each species. Location of each species in a given plot was assigned according to a stratified random design. At 13th Division Prairie 1,000 fescue plugs were planted in early May 1995, 25 plugs in each of 40 plots.

A fire truck equipped with a low-pressure sprinkler was used to water plants immediately after planting. After watering, screened compost mulch was applied to treatment plots, at a rate of one-half liter per plant. Mulch was approximately 3 cm. deep for a radius of 7 cm. around each plug.

Watering

Plots at Mortar Point 10 periodically received approximately equal amounts of water via a low-pressure sprinkler from the fire truck. Plots were watered during dry summer months of 1995 as availability of equipment and access to the site permitted. All plots were watered immediately after planting. Subsequently, half of the plots at 13th Division Prairie were watered, via drip irrigation, from mid-July through September 1995. An average of approximately 1.3 cm. of water was applied biweekly over the 4 m^2 area of each irrigated plot.

Data Collection

Data recorded include survivorship, green length of the longest leaf in each planted Idaho fescue plug, diameter of planted Idaho fescue bunches, and, in the second year, number of flowering stems per bunch at Mortar Point 10.

To minimize edge effects, measurements were taken on plants in a 2-meter by 2-meter interior subplot of each larger 3-meter by 3-meter plot at Mortar Point 10. Sampling of the 2-meter by 2-meter plots at 13th Division Prairie was done in 1-meter-square interior subplots.

Basal diameter and the green length of the longest leaf of each Idaho fescue plug were recorded immediately after planting, in April 1995 at Mortar Point 10, and in May 1995 at 13th Division Prairie. Additional diameter and length measurements of fescue bunches in each plot at Mortar Point 10 were taken in July and October 1995 and in April and July 1996. Additional measurements at 13th Division Prairie were taken in November 1995 and in May 1996.

Analysis of variance (ANOVA) was used to compare mortality and growth of fescue under different treatments and planting schemes.

TABLE 1. ANOVA of *Festuca idahoensis* growth and mortality, April 1995 to July 1996, Mortar Point 10. Tests for interaction effects are not shown here, but ANOVA revealed no significant interaction between application of mulch and planting scheme used.

	Diameter				Flowering Stems				Mortality			
Source of Variation	**df**	**MS**	***F***	***P***	**df**	**MS**	***F***	***P***	**df**	**MS**	***F***	***P***
Planting scheme	2, 24	24.374	1.670	0.209	2, 24	75.833	0.983	0.389	2, 24	0.122	0.665	0.524
Mulch	1, 24	24.374	3.034	0.094	1, 24	75.833	0.011	0.917	1, 24	0.122	17.075	**0.000**

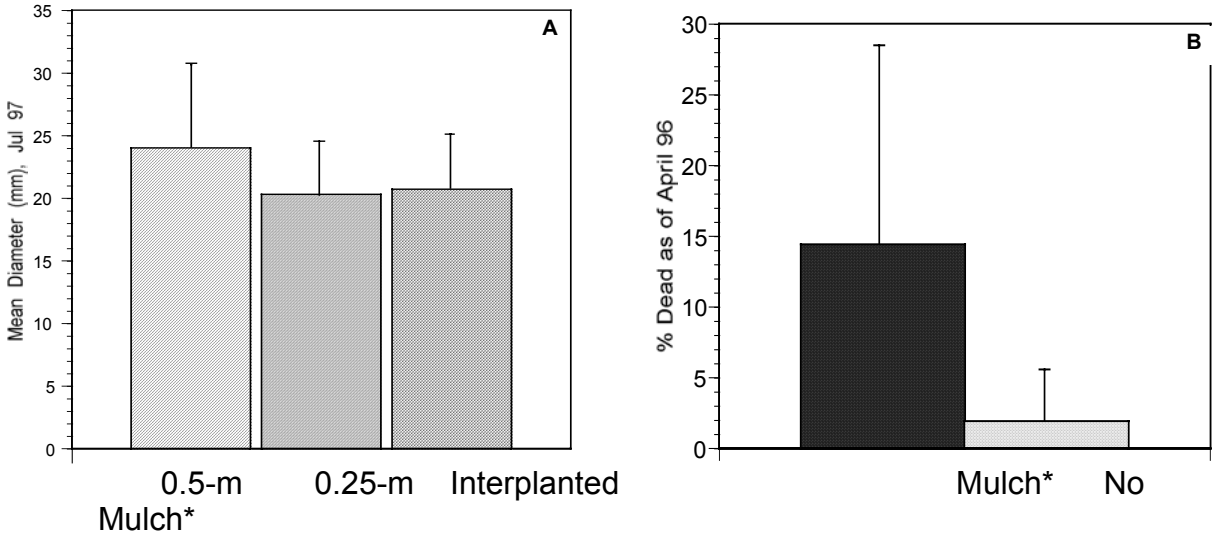

FIG. 1. Mortar Point 10: (A) Mean diameter (mm) of surviving *Festuca idahoensis* plugs as of July 1996. (B) Mortality (% of total planted) as of April 1996. Error bars show +1 SD. Sample size = 10 for each planting scheme.

Results and Discussion

Survival and growth of planted fescue plugs at the two sites contrasts sharply. Fescue plugs planted into bare ground at Mortar Point 10 survived and grew better than plugs planted into, and thus competing with, existing vegetation at 13th Division Prairie. Out of 1,230 plugs planted at Mortar Point 10 in April 1995, 81, or 6.6 percent, were dead by October of the same year. At 13th Division Prairie, 18.6 percent (67 of 360 plugs) died by October 1995, nearly three times the rate of the other site. Growth of surviving plugs also was markedly inhibited by competition at 13th Division Prairie. Increases in basal diameter were substantially smaller than at Mortar Point 10. Initial diameters at both sites were 1-2 mm. (Although leaf length was also measured, basal diameter proved to be a more consistent and reliable indicator of plant size and growth, and is thus used here.)

All plants showed some decline in leaf length after planting, probably the result of transplant stress and the changed conditions

of soil and season after transplanting. Plants at Mortar Point 10 that survived until October showed large gains in diameter, with mean increases of from 9 to 11 mm, from an initial diameter of 1-2 mm. In contrast, even the most successful fescue planted at 13th Division Prairie increased average basal diameter by less than 2 mm after one year.

As indicated in Table 1 and Figure 1B, the only significant effect of any treatment at Mortar Point 10 was the dramatically higher mortality for mulched plants ($P<0.001$). Mulch piled around wispy new plugs of fescue appeared to inhibit air circulation and to promote the growth of fungal pathogens during the moist spring weather that followed planting. This effect might not have been seen if a small radius immediately surrounding the newly planted plugs had been left clear of mulch. Preliminary indications from cover data suggest that, in addition to killing new fescue plugs, the mulch may have promoted establishment of weedy species at the Mortar Point 10 site by providing safe sites for germination.

Mulch had no effect on growth or flowering of surviving plants. As Table 1 and Figure 1A show, mortality, growth, and flowering were essentially equal under all three planting schemes.

Both herbicide and mulch at 13th Division Prairie had significant positive effects on Idaho fescue growth. The herbicide had a marked effect on the *Agrostis capillaris* that dominated many plots. This grass yellowed and shriveled within one week after herbicide application, while the fescue appeared unharmed. Although the *Agrostis* produced new growth later in the growing season, all treated *Agrostis* failed to flower again until the growing season following the year of treatment.
Other grasses besides *Agrostis* were damaged by the herbicide, including non-native pasture grasses such as *Dactylis glomerata* L. and *Holcus lanatus* L. Two native species, *Koeleria macrantha* (Ledeb.) J.A. Schultes and *Danthonia californica* Bolander, also occur on 13th Division Prairie and were damaged by the herbicide.

The chemical suppression of competition afforded by the herbicide may have been augmented by mechanical suppression afforded by the layer of mulch covering the soil around the mulched fescue plugs. The harmful effects observed at Mortar Point 10 were ameliorated by greater care in application at 13th Division Prairie, which left the immediate radius around the new plugs clear. In addition, competing vegetation immediately adjacent to new plugs was covered by approximately 3 cm. of screened compost.

Because of the difficulty of hauling water to the site, watering was relatively infrequent and shallow. The volume and frequency of irrigation was too low to have any impact on survival and growth, particularly during a relative cool and damp summer.

TABLE 2. ANOVA of *Festuca idahoensis* growth and mortality, May 1995 to May 1996, 13th Division Prairie. ANOVA revealed no significant 2-way (Herbicide X Mulch, Herbicide X Water, Mulch X Water) or 3-way (Herbicide X Mulch X Water) interactions ($0.915 \geq P \geq 0.144$).

	Diameter				Length				Mortality			
Source of Variation	df	MS	*F*	*P*	df	MS	*F*	*P*	df	MS	*F*	*P*

Herbicide	1, 32	7.966	7.892	**0.008**	1, 32	152.881	0.233	0.633	1, 32	0.225	0.105	0.748
Mulch	1, 32	8.959	8.876	**0.005**	1, 32	6436.369	9.811	**0.004**	1, 32	5.625	2.616	0.116
Water	1, 32	0.398	0.394	0.534	1, 32	3.969	0.006	0.938	1, 32	4.225	1.965	0.171

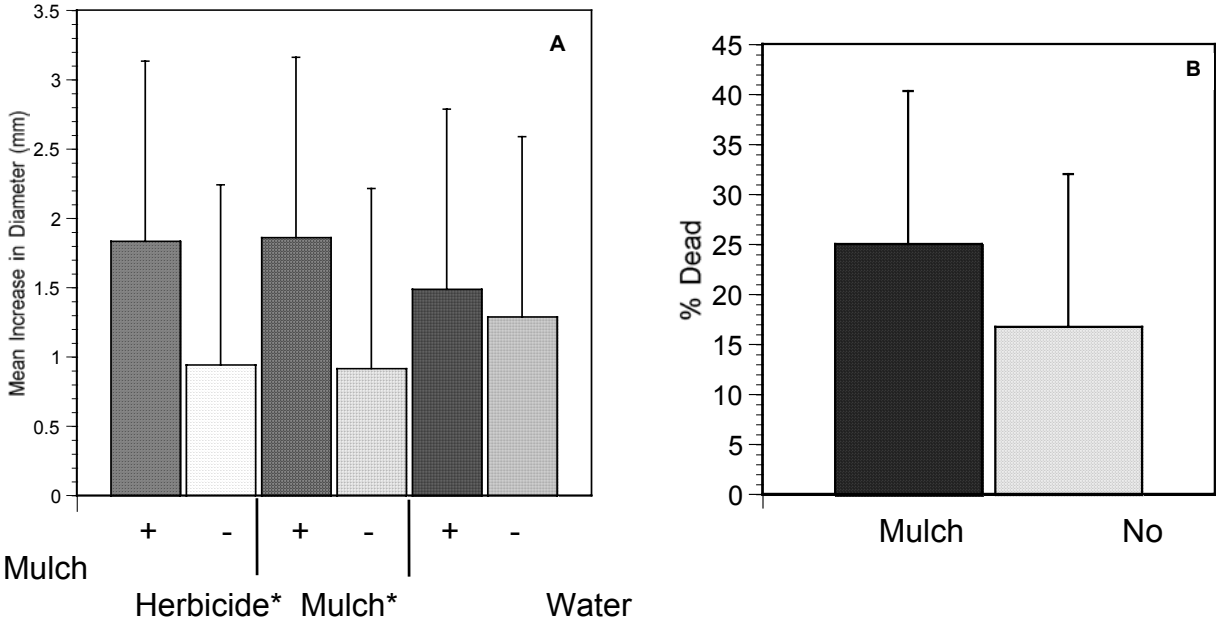

FIG. 2. 13th Division Prairie. (A) Increase in diameter (mm) of surviving *Festuca idahoensis* plugs from May 1995 to May 1996. (B) Mortality (% of total planted) as of May 1996. Error bars show +1 SD. Sample size = 20 for all treatments.

***Means within treatment group were significantly different ($P < 0.01$).**

Conclusions

When planted into bare soil or with minimal competition, small plugs of *Festuca idahoensis* can grow rapidly into robust and fertile plants. After initial planting and watering, the trouble and expense of mulching, fertilizing, and watering fescue plugs planted into bare soil provides little benefit, and may promote colonization by undesirable species.

A different approach may be more successful in a degraded grassland system dominated or seriously invaded by non-native, rhizomatous grasses such as *Agrostis capillaris*. Using both mulch and grass-specific herbicide, together with planting native bunchgrasses, may be a worthwhile means of helping Idaho fescue recover to a more dominant position. Provided the herbicide is relatively benign, and desirable native grasses are assisted in recovering from incidental damage, this could prove to be a cost-effective technique.

References:

Evans, S. A., M.E. Gilber, C.S. Johnson and J. Pl Schuett. 1975. The *Pseudotsuga menziesii* Invasion on Mima Prairie: A Study of Prairie-Forest Dynamics. Pages 63-108 *in* S.G. Herman and A. M. Wiedemann, editors. Contributions to the Natural History of Southern Puget Sound Region, Washington. The

Evergreen State College, Olympia, Washington.

Franklin, J. F. and C. T. Dyrness. 1988. Natural Vegetation of Oregon and Washington. Oregon State University Press; Corvallis, Oregon.

Giles, L.J. 1970. The Ecology of the Nounds on Mima Prairie with Special Reference to Douglas Fir Invasion. Unpublished M.S. Thesis. University of Washington; Seattle, Washington.

Kruckeberg, A. R. 1991. The Natural History of Puget Sound Country. University of Washington Press; Seattle, Washington.

Lang, F.A. 1961. A Study of Vegetation Change on the Gravelly Prairies of Pierce and Thurston Counties, Washington. Unpublished M.S. Thesis. University of Washington; Seattle, Washington.

Ross, M.A. and D.J. Childs. 1996. Herbicide Mode-0f-Action Summary. World Wide Web. http://hermes.ecn.purdue.edu:8001/http_dir/acad/agr/extn/agr/acspub/htm;/WS/ws23.html (30 Mar. 1997).

Thomas, T.B. and A.B.Carey. 1996. Endangered, Threatened, and Sensitive Plants of Fort Lewis, Washington: Distribution, Mapping, and Management Recommendations for Species Conservation. Northwest Science 70:148-163.

Wentworth, J.B. 1994. The Demography and Population Dynamics of *Castilleja levisecta,* and Endangered Perennial. Unpublished M.S. Thesis. University of Washington; Seattle, Washington.

REFERENCES

Evans, S. A., M. E. Gilbert, C. S. Johnson and J. P. Schuett. 1975. The *Pseudotsuga menziesii* invasion on Mima Prairie: a study of prairie-forest dynamics. Pages 63-108 *in* S. G. Herman and A. M. Wiedemann, editors. Contributions to the natural history of the southern Puget Sound region, Washington. The Evergreen State College, Olympia, Washington.

Franklin, J. F. and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, Oregon.

Giles, L. J. 1970. The ecology of the mounds on Mima Prairie with special reference to Douglas-fir invasion. Unpubl. M.S. thesis. University of Washington, Seattle, Washington.

Kruckeberg, A. R. 1991. The natural history of Puget Sound country. University of Washington Press, Seattle, Washington.

Lang, F. A. 1961. A study of vegetation change on the gravelly prairies of Pierce and Thurston Counties, Washington. Unpubl. M.S. thesis. University of Washington, Seattle, Washington.

Ross, M. A. and D. J. Childs. 1996. Herbicide mode-of-action summary. World Wide Web. <http://hermes.ecn.purdue.edu:8001/http_dir/acad/agr/extn/agr/acspub/html/WS/ws23.html> (30 Mar. 1997).

Thomas, T. B. and A. B. Carey. 1996. Endangered, threatened, and sensitive plants of Fort Lewis, Washington: distribution, mapping, and management recommendations for species conservation. Northwest Science **70**:148-163.

Wentworth, J. B. 1994. The demography and population dynamics of *Castilleja levisecta*, an endangered perennial. Unpubl. M.S. thesis. University of Washington, Seattle, Washington.