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FIRE EFFECTS ON PRAIRIE VEGETATION FORT LEWIS, WASHINGTON

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Abstract

Fort Lewis is an excellent site to determine the effects of different fire regimes on prairie vegetation. Fort Lewis has three widely divergent, documented fire return intervals in a small area with uniform soils. These fire regimes include: a) fire suppression, b) prescribed burning on a 3-5 year rotation and c) the annual burning of the Artillery Impact Area ignited from exploding ordinance.

Fire suppression affects a much greater area on Fort Lewis and is more harmful to prairie vegetation than excessive burning. Fire suppression allows *Psuedotsuga* and *Cytisus* to invade prairies which in turn eliminate prairie vegetation. Vegetation responses one growing season post prescribed fire were varied. *Festuca idahoensis, Lupinus lepidus* and *Hypochaeris radicata* decreased in cover after both spring and fall burns. Species that increased in cover included non-vascular crytopgams, *Luzula campestris*, *Microseris laciniatus*, *Rumex acetosella* and *Lomatium triternatum*. Annual burning within the Artillery Impact Zone has resulted in a significant alteration in the vegetation. Festuca idahoensis is merely a minor component, while the non-native *Anthoxanthum aristatum* and *Hypochaeris radicata* dominate. These effects are similar to many prairie fire studies throughout the American West.

INTRODUCTION

Fire is a natural part of the prairie environment. Prairies are often fire stable communities that are maintained by frequent, low intensity ground fires that continually exclude invasive, fire sensitive species (Anderson and Brown 1986, White 1986, Agee 1993). Some prairie communities in western Washington are fire dependent, persisting only where fires prevent more competitive, fire sensitive species from displacing them.

Since modern settlement, fire suppression has reduced fire incidence throughout many vegetation types, so that many fire dependent plant communities have been invaded by fire sensitive species (Cooper 1961, Weaver 1964, Agee 1993). Fire suppression also permits unnaturally high levels of fuels to develop, allowing hot fires to threaten normally fire tolerant vegetation (Habeck and Mutch 1973, Griffin 1977). Prescribed fire programs have been developed to reduce fuels and maintain fire dependent communities.

Many authors have noted that prairie species tolerate fire extremely well (Anderson 1964, Old 1969, Antos et al. 1986, White 1986, Sugihara and Reed 1987). Fires maintain prairies by killing invading trees and shrubs (Thilenius 1964, Nimir and Payne 1978, Griffin 1977, Gruell et al. 1986). Both Antos et al. (1986) and Nimir and Payne (1978) quantified the effects of fire on prairies in Montana with species composition similar to the prairies on Fort Lewis. Spring prescribed fires set by Nimer and Payne (1978) initially changed the cover of some prairie species, but those differences decreased throughout the first growing season. Antos et al. (1986) observed that a summer wildfire initially reduced *Festuca idahoensis* cover and increased total forb cover. Significant changes in cover, however, lasted three years or less.

Fire suppression has allowed 6,560 ha of the original 16,800 ha of prairie on Fort Lewis to be converted into *Pseudotsuga menziesii* forests since 1870. Nearly all prairie vegetation is lost following the invasion of *Pseudotsuga menziesii*. Presently, only a fraction of the original prairie area remains as small, isolated prairies. The largest remaining prairie on Fort Lewis is in the Artillery Impact Area which burns nearly annuals due to military training exercises. The other remaining prairies roughly define the boundaries of lands included in a prescribed burning program.

Three fire regimes exist on Fort Lewis. The first and most widespread fire regime is fire suppression. Fire is suppressed on nearly 28,000 of the 34,865 ha Fort Lewis. Where fire has been suppressed on prairies and *Quercus* woodlands, *Pseudotsuga* and *Cytisus* have eliminated most prairie vegetation. The second fire regime is the spring prescribed fire program. The prescribed fire program burns 3000 ha of prairies and *Quercus* woodlands on a 3-5 year rotation. Most prescribed fires are set in February and March but fires are also set in the fall. The third fire regime is annual burning within the 3000 ha Artillery Impact Area. Within the Artillery Impact Area, a 1000-1200 ha area where bombing is concentrated has burned nearly annually for 50 years Artillery Impact Area fires burn throughout the year, but most fires occur in the summer.

Fort Lewis is an excellent site to determine the effects of different fire regimes on prairie vegetation. Fort Lewis has three widely divergent, documented fire return intervals in a small area with uniform soils. It is the only site in western Washington with a long standing program of consistent prescribed burning, and it contains many of the largest, highest quality prairies in western Washington. This study was designed to answer 3 questions. 1) What prairie plant communities have developed as a result the prescribed burning program and annual burning in the Artillery Impact Area on Fort Lewis? 2) What fire regime best promotes native prairie vegetation? 3) Do fall prescribed fires affect prairie vegetation differently from spring fires?

METHODS

Community Composition

The effects of fire on Wier Prairie and Artillery Impact Area vegetation were evaluated using 180 1-m^2 plots arranged

along transects that varied in length from 60 to 180 m. The 1-m^2 plots were located on the transects at alternate meters, which allowed a buffer zone for the different treatments.

Baseline compositional data were gathered May to August 1994, and post-fire data were gathered on the same plots May to July 1995. No final data were gathered were analyzed in the Artillery Impact Area where I did not set prescribed fires. Cover (C' ; as canopy coverage) was estimated to the nearest 1%. Foliage density (FD) was estimated to the nearest 5%, expressed as a decimal. Weighted cover (C), the value used in this assessment, was calculated as C=C' x FD. This type of cover estimate was necessary because fire often reduces the thickness of the foliage without changing the canopy spread of the plants. Only species with at least 0.1% mean cover in either the initial or final surveys were included in any tables. Following the final inventory species were classified as fire decreasers, fire increasers or fire neutral. In order for a species to be classified as a fire decreaser, the prescribed fires must have significantly reduced its mean cover or lowered its frequency by at least 300%. Fire increasers were species that significantly increased in cover or increased at least 300% in frequency following fires. All other species were considered fire neutral.

Fire Treatments

The plots were randomly assigned to three treatments, with approximately 30% to be burned in the spring, 30% to be burned in the fall, and 30% left unburned (Table 1). Plots that were not scheduled to be burned were soaked with water. All prescribed fires were set with ambient temperatures between 10-20^0 C and relative humidity between 20-50%. Winds speeds were less than 5 kph during all fires, except on Wier Prairie in the spring where gusts reached 10 kph causing fires to escape and burn all 30 of the plots that I had intended to keep unburned (Table 1). Wier prairie fires
were set in September 1994 (30 plots) and March 1995 (60 plots). All 90 Artillery Impact Area plots were burned in a single August 1994 wildfire.

Temperatures of Prescribed Fires

Fire temperatures were measured in all communities burned in this study, using OMEGALAQ temperature-indicating paints that melt at 142^0, 246^0, 343^0, 427^0, 538^0, and 649^0 C (Table 1). The paints were applied to metal plates placed on the ground in each community before the fires were set.

Table 1. Percent of heat sampling paints burned at different fire temperatures (^{0}C) by vegetation type and fire season.

Vegetation Type	Fire season	Total plates	142^0	246^0	343^0	427^0	538^0
Wier Prairie	Spring	30	43%	54%	3%	_	_
	Fall	30	3%	77%	20%	_	_
Artillery Impact Area	Summer	27	71%	29%	_	_	_

Experimental Design and Statistical Analysis

The research was designed to fit analysis of variance models with the significance level set at 5% before the research started. All fire treatment effects on species cover were analyzed using a randomized complete block design ANOVA. Significant differences were determined by Newman-Keuls multiple range test. Nomenclature follows Hitchcock and Cronquist (1976) for vascular plants.

RESULTS

Wier Prairie

Wier Prairie, a diverse community dominated by native prairie species, was presumed to be the closest approximation to the natural vegetative type at Fort Lewis (Table 2). The vegetation was sparse with 61.6% cover by vascular species and 22.6% cover by non-vascular cryptogams, principally mosses. Non-vegetated areas consisted of bare ground, rock, and litter. Under the current 3-5 year fire rotation, the bunchgrass *Festuca idahoensis* dominated Wier Prairie. *Hypochaeris radicata* was the most important prairie forb. Both species were continuously distributed throughout the sample area. Many subordinate species including *Eriophyllum lanatum, Lupinus lepidus, Agrostis tenuis, Plantago lanceolata, Luzula campestis,* and *Carex pensylvanica* had low cover values but were nearly continuously distributed with frequencies greater than 80%. Several species including *Hieracium cynoglossoides*

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Table 3. Mean percent cover and frequency of Wier Prairie species with at least 0.1% cover. Wier Prairie is on a 3-5 year fire rotation and plots were last burned 3 years prior to the initial survey.

Species	Cover	Frequency
Festuca idahoensis	39.9	100
Hypochaeris radicata	7.8	100
Hieracium cynoglossoides	2.0	66
Eriophyllum lanatum	1.7	94
Lupinus lepidus	1.4	92
Lupinus albicaulis	1.1	12
Panicum occidentale	1.0	71
Agrostis tenuis	0.9	81
Danthonia californica	0.8	94
Plantago lanceolata	0.7	90
Luzula campestris	0.5	98
Carex pensylvanica	0.4	89
Chrysanthemum leucanthemum	0.4	36

Solidago missouriensis	0.4	23
Achillea millefolium	0.3	54
Koeleria cristata	0.3	41
Festuca rubra	0.3	41
Arctostaphylos uva-ursi	0.3	1
Panicum scribnerianum	0.1	12
Aira praecox	0.1	99
Hypericum perforatum	0.1	61
Microseris laciniatus	0.1	59
Non-vascular cryptogams	22.6	100

Panicum occidentale, Chrysanthemum leucanthemum, and *Achillea millefolium* grew in contagious groups. *Lupinus albicaulis,* a large plant, was the most important among several infrequent species.

Response of Wier Prairie vegetation to spring and fall prescribed burning is summarized in Table 3. *Festuca idahoensis, Hypochaeris radicata*, and *Lupinus lepidus* were recognized as fire decreasers. Although both spring and fall burning significantly reduced *Festuca idahoensis* cover, no *Festuca idahoensis* bunches were killed. One growing season was insufficient time for *Festuca idahoensis* to replace foliage lost in the fires. *Hypochaeris radicata* .

cover also was significantly reduced but dense reproduction was present. Nearly all *Lupinus lepidus* plants were killed by the fires, so that the post fire *Lupinus lepidus* shown in Table 4 were small, recently sprouted seedlings. Non-vascular cryptogams increased after fire, as did four vascular species, all minor subordinates. *Luzula campestris*, *Microseris laciniatus,* and *Rumex acetosella* increased significantly following both spring and fall fires. *Lomatium triternatum* only increased after spring burning. Most subordinate species were not significantly affected by fire. They remained fire neutral, regardless of fire season

Table 3. Mean percent cover (C) and frequency (F) changes of Wier Prairie species in response to spring and fall prescribed fires. Bold indicates a significant change in either cover with p <0.05 or a three fold change in frequency. Only species with at least 0.1% cover either before or after the fires were included.

	Fall burn				Spring burn			
	Before		After		Before		After	
	C	F	C	F	C	F	C	F
Fire decreasers								
Festuca idahoensis	40.8	100	**11.7**	100	39.4	100	**9.1**	100

Hypochaeris radicata	7.9	100	**4.5**	100	7.7	100	**5.7**	100
Lupinus lepidus	1.3	87	**0.4**	97	1.5	95	**0.3**	78
Fire increasers								
Non-vasc. cryptogams	25.1	100	**37.5**	100	21.5	100	**26.4**	100
Luzula campestris	0.6	100	**1.1**	100	0.4	98	**0.7**	80
Microseris laciniatus	0.1	67	**0.4**	70	0.1	55	**0.3**	67
Rumex acetosella	<0.1	70	**0.2**	67	<0.1	63	**0.1**	62
Lomatium triternatum	<0.1	23	0.2	30	0.1	33	**0.3**	40
Fire neutral								
Hieracium cynoglossoides	2.4	70	3.1	70	1.8	63	2.0	58
Eriophyllum lanatum	1.8	93	1.4	97	1.7	93	1.2	95
Panicum occidentalis	0.9	73	0.6	63	1.0	70	0.8	65
Agrostis tenuis	0.9	80	0.8	77	0.8	82	0.7	80
Danthonia californica	0.8	90	0.7	97	0.9	97	0.8	95
Plantago lanceolata	0.7	90	0.5	90	0.6	90	0.8	87
Solidago missouriensis	0.2	30	0.2	23	0.5	20	0.5	32
C. leucanthemum	0.1	20	<0.1	23	0.5	43	0.4	45
Achillea millefolium	0.2	30	0.3	37	0.3	66	0.4	53
Koeleria cristata	0.1	30	0.1	40	0.3	40	0.3	52
Festuca rubra	0.3	47	0.3	67	0.2	38	0.1	53

Artillery Impact Area

Annual burning in the Artillery Impact Area causes sparsely developed vegetation. Mean cover of vascular plants was 39.5% and non-vascular cryptograms covered 9.4% of the sample area. The remaining area comprised bare ground and rocks. *Hypochaeris radicata* and *Anthoxanthum aristatum* dominated (Table 4). *Anthoxanthum aristatum* is an introduced annual grass, absent on Wier Prairie and uncommon anywhere on Fort Lewis except for the Artillery Impact Area. Several subordinate graminoids, including *Festuca rubra, Panicum scribnerianum, Luzula campestris,* and *Holcus lanatus* are favored by annual burning. Compared to Wier Prairie, the cover of most prairie species was significantly lower in the Artillery Impact Area, and many species were absent. *Festuca idahoensis* was merely a minor component of the Artillery Impact Area vegetation. Absent species included *Lupinus albicaulis, Lupinus lepidus,* and *Danthonia californica.* Only *Agrostis tenuis* cover was not significantly different from Wier Prairie. Most of the plant cover on the Artillery Impact Area plots consisted of non-native species, but many native species were present as subordinate members of the community.

Table 4. Mean percent cover and frequency of the Artillery Impact Area species with at least 0.1% cover. Training-caused fires burn the sample area annually.

Species	Cover	Frequency
Hypochaeris radicata	19.1	100
Anthoxanthum aristatum	9.8	100
Festuca rubra	2.6	98
Panicum scribnerianum	2.0	58
Agrostis tenuis	2.1	58
Luzula campestris	1.3	98
Holcus lanatus	0.5	30
Panicum occidentale	0.4	6
Hieracium cynoglossoides	0.3	21
Rumex acetosella	0.2	63
Koeleria cristata	0.2	8
Apocynum andraesemifolium	0.2	16
Festuca idahoensis	0.1	8
Solidago missouriensis	0.1	24
Carex pensylvanica	0.1	20
Non-vascular cryptogams	9.4	100

DISCUSSION

Fire Effects on Community Dynamics

Prairie species are fire adapted to frequent fires, so that the prescribed fires did not cause permanent damage to Wier Prairie vegetation, regardless of fire season (Tables 2 and 3). The present species composition on Wier Prairie has been maintained using prescribed fires for twenty years. The fires I set were an extension of the existing prescribed burning plan, but with fall fires added to determine the effects of fire season on vegetation. Prescribed fires temporarily reduced *Festuca idahoensis* cover, but did not remove *Festuca idahoensis* as the dominant prairie species. Prescribed fires caused no significant changes to most native or introduced subordinates, nor to species diversity.

Excessive burning harms most native prairie species. Fifty years of annual burning on 1000-1200 ha within the Artillery Impact Area has changed native perennial bunchgrass prairies to introduced forb and annual grass dominated prairies (Table 4). Compared to Wier Prairie, native plant cover and species diversity were significantly lower. The displacement of *Festuca idahoensis* as the dominant species and the absence of several native species indicated that the native prairie community is not adapted to prolonged annual burning.

Fire suppression affects a much greater area on Fort Lewis and is more harmful to prairie vegetation than excessive

burning. Fire suppression allows *Pseudotsuga* and *Cytisus* to invade prairies which in turn eliminate prairie vegetation.

The fires on Fort Lewis produced effects similar to many prairie fire studies throughout the American West.. As observed in Montana(Antos et al. 1986), the Wier Prairie fires significantly reduced *Festuca idahoensis* cover but did not affect species diversity or species composition. Of two spring fires set by Nimir and Payne (1978) in Idaho, one significantly reduced *Festuca idahoensis* and total forb cover, but the other fire did not significantly affect either. Fort Lewis fires were followed by rapid herbaceous growth, similar to responses noted in California (Sugihara and Reed 1987) and Minnesota (White 1986) after fires removed dead grass and shrubs.

Some fire effects on Fort Lewis were different from results observed elsewhere. Fires were followed by higher forb cover in California prairies and *Quercus* woodlands (Sugihara and Reed 1987), Montana prairies (Antos et al. 198), and *Quercus* savannas in Minnesota (White 1986) but not in the corresponding communities at Fort Lewis. Likewise, Antos et al. (1986) observed lower non-vascular cover following fire in Montana in contrast to higher non-vascular cover following fires on Wier Prairie.

Without frequent prairie fires, most of Western Washingtons's prairies are gradually being lost to invading *Pseudotsuga menziesii* forests or *Cytisus* shrublands . Fire is necessary to prevent the loss of prairies. Too much fire, however, damages native prairie communities. Annual burning in the Artillery Impact Area has reduced the cover and diversity of most native prairie species. This study shows that native prairie species are adapted to withstand and thrive in the presence of frequent fires (every 3-5 years). Under the present prescribed burning plan a diverse, native species dominated prairie community has persisted and thrived for more than 20 years. Also this study shows that prairire vegetation response is essentially the same for both spring and fall prescribed fires. Fort Lewis has developed the best fire regime known to maintain native prairies in Western Washington. Much remains to be learned about fire effects on prairie vegetation. Hopefully, more will be learned as presribed burning plans are developed and implemented in other prairie areas of Western Washington.

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