Ecological Survey and Interpretation of the Willamette Floodplain Research Natural Area, W.L. Finley National Wildlife Refuge, Oregon, USA

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ABSTRACT: Ecological data from the Willamette Floodplain Research Natural Area were analyzed in order to characterize present-day vegetation and evaluate its relation to environmental controls. An additional objective was to establish baseline data for future analysis of plant species response to fire. Vegetation data collected from 36 random permanent plots were classified by two-way indicator species analysis and ordinated by Nonmetric Multidimensional Scaling. Two major communities prevail in the research area. One dominates slightly elevated mounds and is marked by tall, dense *Rosa eglanteria* and *Hypericum perforatum* together with many other alien species. The other is found in depressed intermounds and is dominated by shorter but also dense *Rosa eglanteria, Deschampsia cespitosa,* and many native species with wetland affinities including monotypic patches of *Spiraea douglasii*. Species composition strongly correlated with microtopography relating to an indirect soil moisture index based on wetland status of individual species. We failed to reject vegetation-environmental relationships through hypothesis testing using the nonparametric Multi-Response Permutation Procedure. Vegetation on mounds differed significantly from that on intermounds and correlated with recent burning history.

Index terms: fire history, prescribed burning, wetland index, Willamette Valley, wet prairie

INTRODUCTION

Oak savanna, wet and dry prairie, marsh, deciduous riparian woodland, and deciduous and coniferous forest were common Willamette Valley vegetative formations when Euro-Americans settled the area in the mid-nineteenth century (Habeck 1961, Johannessen et al. 1971, Towle 1982). Extensive oak savanna and prairie were apparently maintained by Kalapuya Indians through burning, which promoted growth of their preferred plants and provided wildlife habitat (Boyd 1986, Boag 1992).

Little is known of the composition and structure of the presettlement wet prairie vegetation, although altered remnants of these relatively undisturbed formations persist in a few locations. Since the mid-1800s, native grasses not adapted to livestock grazing have mostly been replaced by alien species. Today, grass seed production is one of the dominant agricultural activities in original wet prairie areas.

Several studies related to restoring putative presettlement vegetation and maintaining rare species through the use of prescribed burning have been undertaken in various Willamette Valley sites since the mid-1980s (The Nature Conservancy 1989, Acker 1990, Connelly and Kauffman 1991, Wilson et al. 1993, Pendergrass 1996). In the present study, W.L. Finley National Wildlife Refuge personnel proposed use of prescribed burning to control invasive alien species and reduce shrub and tree cover in the Willamette Floodplain Research Natural Area (RNA), located within the Refuge.

Objectives

We surveyed RNA vegetation in the early summer of 1991 after one experimental prescription fire in September 1990 in the northwest section of the RNA. Our research objectives were to (1) provide a baseline description of the RNA vegetation, (2) test for differences in plant species composition between areas with different microtopographic position reflecting differences in moisture, and (3) determine effects of historic burning on vegetation composition. Our study also established a sampling system for future analysis of plant species response to different fire frequencies.

STUDY AREA

The study site, a 210-ha tract of wet prairie within the RNA (lat. 123° 18', long. 44° 25'), is located 16 km south of Corvallis in the Willamette Valley (Figure 1). The RNA was established by the U.S. Fish and Wildlife Service in 1966 to provide a yardstick for long-term scientific studies and to serve as a refuge for sensitive biota (Franklin 1972). Refuge staff assumed that the prairie was unplowed and represented a nearly native grassland ecosystem (sensu Wilson et al. 1991).

Topography is generally flat with elevation ranging from 82 to 88 m. Aerial photographs, however, exhibit lenticular-shaped features (approximately 150 x 70 m) that are about 50 cm higher than the surrounding topographic matrix, leading to the terminology "mound" and "intermound" used in this study. The study area is periodically flooded by direct rainfall from November to April, with intermounds typically exposed above ponded areas.

Soils consist of valley bottom alluvium underlain by unconsolidated silt, sands, and gravels of late Holocene age, known as the Willamette silts (Franklin 1972, Knezevich 1975). Current climate is cool and wet in winter, and warm and dry in summer, with average January and July temperatures of 4.0 °C and 18.9 °C, respectively. Average annual rainfall is 1,004 mm, of which 47 mm falls between June and August (Franklin and Dyrness 1988). Vegetation consists mostly of grasses and shrubs, with wooded areas dominated by *Fraxinus latifolia* in riparian strips along Muddy Creek.

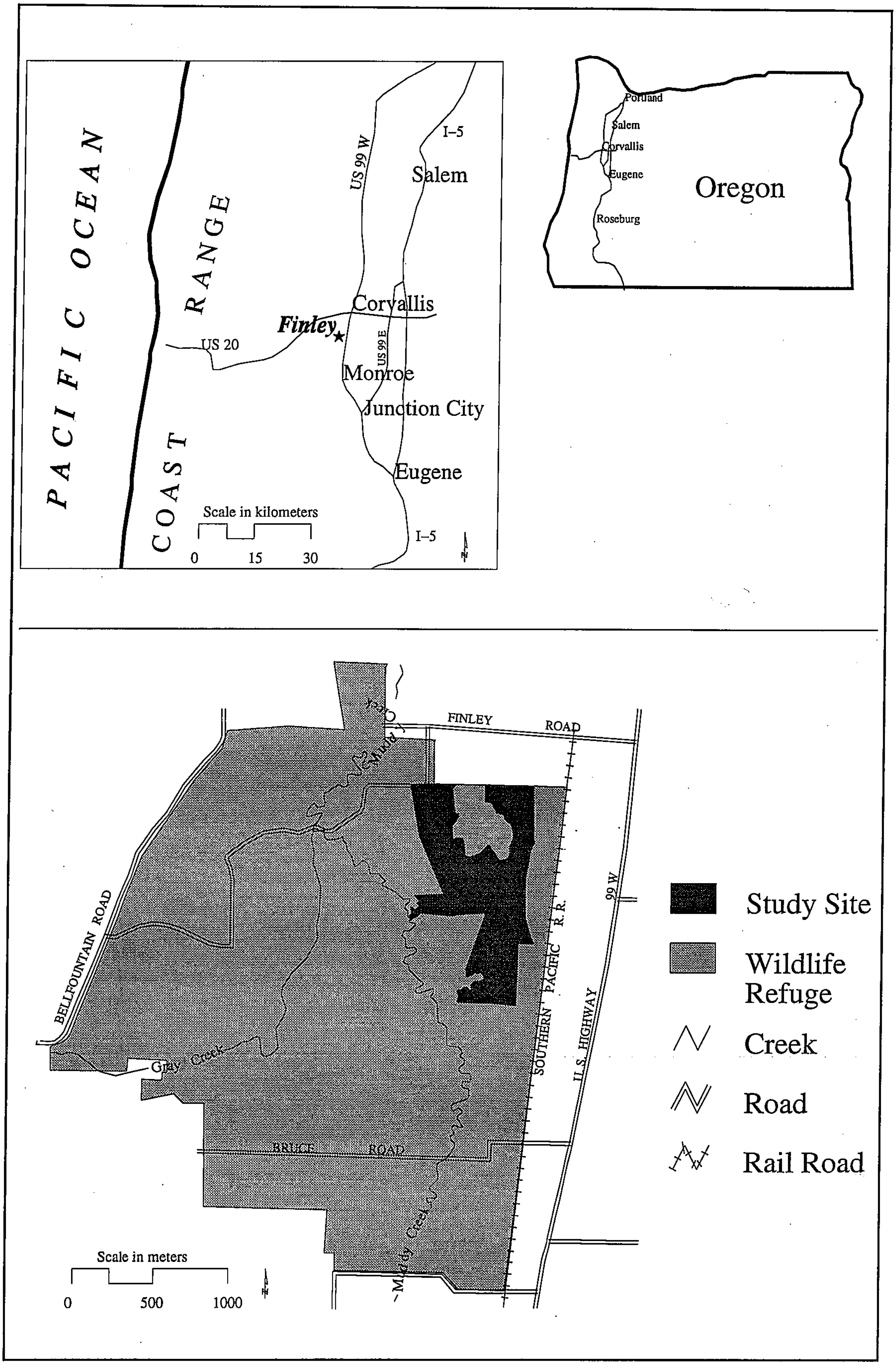

Figure 1. Willamette Floodplain Research Natural Area study site in W.L. Finley National Wildlife Refuge.

Grassland consists of mixtures of graminoids including *Deschampsia cespitosa, Holcus lanatus, Agrostis* spp. and *Carex* spp.; forbs such as *Hypericum perforatum, Galium* spp., and *Vicia* spp; shrubs including *Rosa* spp. and *Spiraea douglasii*; and scattered trees, particularly *Crataegus douglasii* and *Fraxinus latifolia*. Taxonomic nomenclature follows Hitchcock and Cronquist (1973).

Fire history since RNA establishment in the mid-1960s is well documented and complex. No fires are recorded until the early 1970s, when two unpublished studies in 1972 and 1976 included prescription burns in the northeast corner and in a small area in the southern portion of the RNA, respectively. The entire area was burned accidentally in 1979. Three small plots were burned in the northwestern part of the RNA in 1983 during a small mammal study (unpublished). In 1985–87, sections of the southeast corner were burned.

Based on historic accounts, we assume that, at the time of settlement in the mid-nineteenth century, the RNA was predominantly wet prairie maintained by aboriginal burning (Habeck 1961, Johannessen et al. 1971, Moir and Mika 1972, Towle 1982, Boyd 1986, Boag 1992). Periodic burning may have continued well into the late nineteenth century. The prairie was grazed heavily in the early part of the twentieth century. Although the RNA is believed by refuge staff to have never been plowed or farmed, aerial photographs from 1936 show plowlike soil surface disturbance on several mounds and a few shallow ditches. Intermounds probably were not agriculturally manipulated, but received heavy cattle grazing and trampling, which may have altered soil surface structure. According to refuge personnel, livestock grazing ceased when the RNA was established in 1966.

With livestock removal, a generally erratic burning program, and an extended period without fire over the past half-century, shrub cover increased markedly. Recent aerial photographs provide evidence for this, as do anecdotes from former and present refuge staff. The RNA is now heavily dominated by an exotic rose (*Rosa eglanteria*).

METHODS

We established 36 random 25 x 25 m permanent macroplots, distributed equally among mounds and intermounds, in four (approximately 20–40 ha) treatment areas (hereafter called "spaces") differing in fire history and projected treatment. Spaces were delineated on a 1990 aerial photograph (1:5100). Plots 1 to 10 were located in space 1 (burned 1990 and to be burned annually), plots 11 to 20 were in space 2 (serving as a control), plots 21 to 30 were in space 3 (to be burned triennially), and plots 31 to 36 were in space 4 (burned 1985–87 and to be burned triennially). We assumed that, except for fire history and microtopography, vegetation was relatively uniform among spaces. This assumption turned out to be false, for there was considerable compositional heterogeneity with no apparent pattern.

Between June 24 and July 23, we sampled the 36 macroplots with 25 randomly located 1-m^2 microplots stratified one per 5 x 5 m block, ensuring even distribution across each macroplot. Because of severe time constraints imposed by having one researcher sample 900 microplots in 4 weeks of field time, we decided to record species importance by a canopy cover index modified after Daubenmire (1959). Based on a species-area analysis, we determined that a 1-m^2 plot was the optimum sample size.

Cover class was converted to percent midpoint cover, then standardized, transformed by arc-sine square root, and analyzed by TWINSPAN, a classification system displaying samples and species in a two-way table in their determined groupings (Hill 1979). We used the nonparametric Multi-response Permutation Procedure (MRPP) to test for statistically significant differences between floristic groups (Mielke et al. 1976, Berry et al. 1980, Zimmerman et al. 1985), and Non-metric Multidimensional Scaling (NMS) as an ordination procedure to assess environmental relationships (McCune 1991). Nonparametric procedures were used because of nonlinear relationships between variables and non-normally distributed floristic data.

Within each microplot we recorded species frequency in a 10 x 10 cm plot. Frequency data were used to calculate a moisture value based on a frequency-weighted average wetland index. Our moisture index employed the National List of Plant Species that Occur in Wetlands: Oregon (Reed 1988), wherein species are rated according to their moisture affinity in five categories ranging from obligate wetland species to upland (nonwetland) species. Species not listed in this compilation were

Table 1. Average percent cover of the 13 most common plant species in mound and intermound macroplots in the Willamette Floodplain RNA, Oregon, USA.

Species	Overall n=36	Intermounds n=19	Mounds n=17
Rosa eglanteria *	41.0	39.4	42.5
Hypericum perforatum *	13.0	0.9	25.3
Holcus lanatus *	8.7	12.2	5.2
Deschampsia cespitosa	8.0	15.8	0.3
Galium parisiense *	7.8	1.2	14.5
Agrostis tenuis *	5.2	5.6	4.3
Myosotis laxa	3.5	5.7	1.4
Epilobium paniculatum	4.3	3.0	5.7
Veronica scutellata	4.9	9.1	0.7
Parentucellia viscosa *	2.5	2.1	3.0
Plagiobothrys figuratus	3.8	6.6	0.9
Madia glomerata	2.6	2.5	2.6
Trifolium dubium *	2.6	0.5	4.8

*alien species

Table 2. Summary of TWINSPAN classification of Willamette Floodplain RNA vegetation showing principal indicator species.

Species (Plot Number →)	32	34	29	30	33	15	22	24	14	17	18	21	16	3	4	5	8	35	36	2	1	6	10	31	7	26	27	13	23	28	20	25	9	11	12	19
Achillea millefolium	1	1	2	1	1	1	1	1	1	-	1	1	-	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Sidalcea campestris	-	1	1	2	2	1	1	1	3	1	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Geranium dissectum *	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia sativa *	1	-	1	1	1	1	1	1	1	1	1	1	-	1	2	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aira caryophyllea *	-	1	-	-	1	-	-	-	-	1	-	-	-	1	1	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cirsium vulgaris *	1	1	1	2	2	1	2	2	1	1	1	1	1	1	-	-	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
Madia sativa	1	1	1	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Poa pratensis *	1	1	1	1	1	1	1	1	-	1	1	1	1	1	-	1	1	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex tumulicola	2	1	1	1	1	1	-	1	1	1	2	2	1	1	1	1	1	1	1	1	-	-	-	1	-	-	-	1	-	-	-	-	-	1	1	-
Trifolium dubium *	1	1	1	1	2	-	1	1	1	1	1	1	1	4	3	5	3	1	1	1	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Galium parisiense *	6	3	5	3	5	2	2	2	1	1	1	4	4	3	4	5	5	2	1	1	2	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-
Anthoxanthum aristata *	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Cerastium viscosum *	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	-	-	-	-	1	1	-	1	1	1	-	-	-	-	-
Rosa eglanteria *	5	2	6	8	7	7	8	7	8	7	7	7	7	4	5	7	7	6	6	2	5	4	5	8	5	7	8	7	7	7	7	7	1	6	3	6
Prunella vulgaris	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	-	-	1	-	1	-	1	1	-	-	-	1	-	1	-	-	-	-
Epilobium glandulosum	-	-	-	-	-	-	-	-	-	1	1	-	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1	1	1	2	1	1	1	1	1
Juncus tenuis	-	-	-	-	-	-	-	-	-	1	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	2
Holcus lanatus *	1	1	2	1	1	2	2	2	1	3	1	1	2	1	2	1	2	3	2	2	3	2	2	4	2	1	3	3	1	3	4	5	1	3	3	5
Veronica scutellata	-	-	1	-	-	-	-	1	1	-	1	1	1	-	1	-	1	-	-	1	1	1	1	1	4	3	5	3	3	2	1	4	-	2	4	2
Carex unilateralis	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1
Beckmannia syzigachne	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	1	-	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	-
Deschampsia cespitosa	-	-	-	-	1	-	1	-	-	1	-	1	1	1	1	-	1	2	3	1	1	2	3	3	1	1	2	5	3	5	4	2	1	6	7	6
Juncus nevadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	2	1	3	3	1	1	-	1	1	1	1
Hordeum brachyantherum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	1	1	2	-	2	2	-	1	1	1	1	-
Plagiobothrys figuratus	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	1	1	1	2	4	4	6	2	1	1	1	1	1	2	1	1	1	1	1	1
TWINSPAN Group	A1												A2						B2							B1										
Microtopography	Mound												Transitional													Intermound										

* alien species

assumed to be upland plants. The wetland index was calculated for each macroplot by the following equation:

$$W_j = \frac{\sum_{i=1}^{p} I_{ij} E_i}{\sum_{i=1}^{p} I_{ij}}$$

where W = Wetland index for macroplot j
I_{ij} = Frequency of the ith species in macroplot j
E_i = Wetland weighting factor for the ith species
P = Number of species in macroplot j

This index follows the procedure of Wentworth et al. (1988). Indices less than 3.0 indicate wetland-associated conditions.

RESULTS

Floristics

A total of 108 vascular plant species occurred in the macroplots: 4 trees, 5 shrubs, 69 forbs, 30 graminoids; 60% were perennials or biennials and 40% were annuals; 65% are indigenous. Total RNA flora was predominantly herbaceous and native; however, because *Rosa eglanteria* dominated, vegetation was structurally a patchy shrubland.

Rosa eglanteria was ubiquitous in all macroplots. *Hypericum perforatum*, the second most dominant, accounted for less than 1% cover on intermounds and more than 25% cover on mounds. Other prominent herbaceous species (mean cover 2.5–10%) are shown in Table 1. Native and introduced species were differentially distributed on intermounds and mounds. Intermounds averaged 73% native species per macroplot, mounds averaged 51%. The major native species found in wetter areas was *Deschampsia cespitosa* and in drier areas it was *Epilobium paniculatum*. Intermound species typically occurred with low cover on mounds, and mound species occurred with low cover on intermound areas. The principal introduced species in wetter areas was *Rosa eglanteria*.

Table 3. MRPP test of TWINSPAN classification of Willamette Floodplain RNA vegetation by space, showing strength of floristic differences between spaces with respect to two primary TWINSPAN groups.

TWINSPAN Group A vs. Group B	MRPP Test[a]
All plots (n=36)	T = -17.92, p = 0.000
Space 1 plots (n=10)	T = -2.98, p = 0.020
Space 2 plots (n=10)	T = -5.37, p = 0.002
Space 3 plots (n=10)	T = -5.77, p = 0.002
Space 4 plots (n=6)	T = -2.77, p = 0.020

[a] T = Kendall's coefficient of rank correlation, Tau

Microtopography and Moisture

In accord with our first two objectives, describing RNA vegetation and its environmental relationships, we classified and ordinated the floristic data. At the first TWINSPAN classification level, macroplots separated into 17 mound plots (TWINSPAN Group A) and 19 intermound plots (TWINSPAN Group B). At the second classification level, two transitional communities (TWINSPAN Groups A2 and B2) became evident (Table 2).

We statistically tested the TWINSPAN classification with the MRPP to assess the strength of floristic difference between groups by space. For all spaces and macroplots combined there was a very strong statistical difference between mound and intermound plots (Table 3). When we tested mound plots against intermound plots by individual space, eliminating fire history effects, species composition again differed significantly between mounds and intermounds in each space.

NMS ordination of macroplots also showed clear separation of mound and intermound plots; the latter were positioned to the right of the ordination (Figure 2). Since

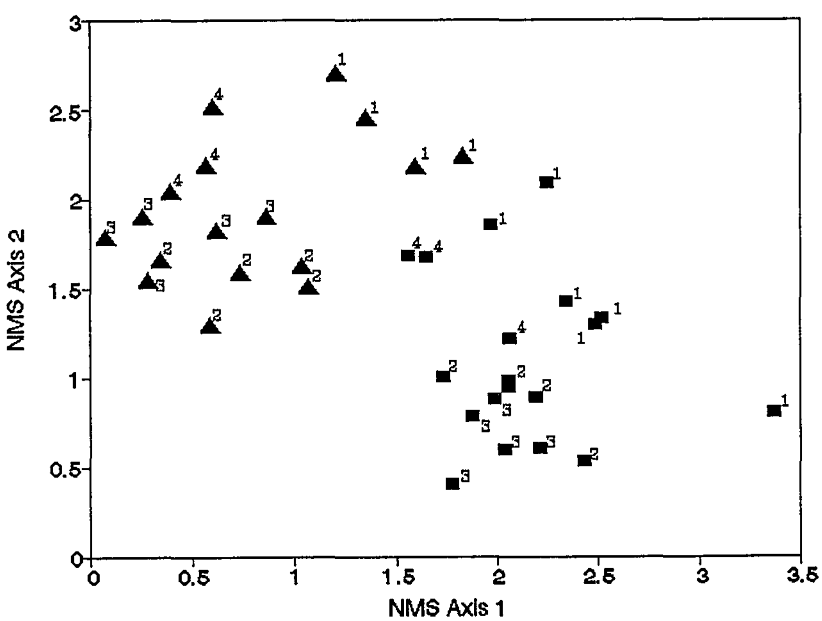

Figure 2. NMS ordination of floristic data from 36 macroplots in the Willamette Floodplain RNA. Triangles indicate mounds, squares indicate intermounds, and numbers refer to research spaces. Axis 1 correlates with moisture and axis 2 correlates with time since last burn.

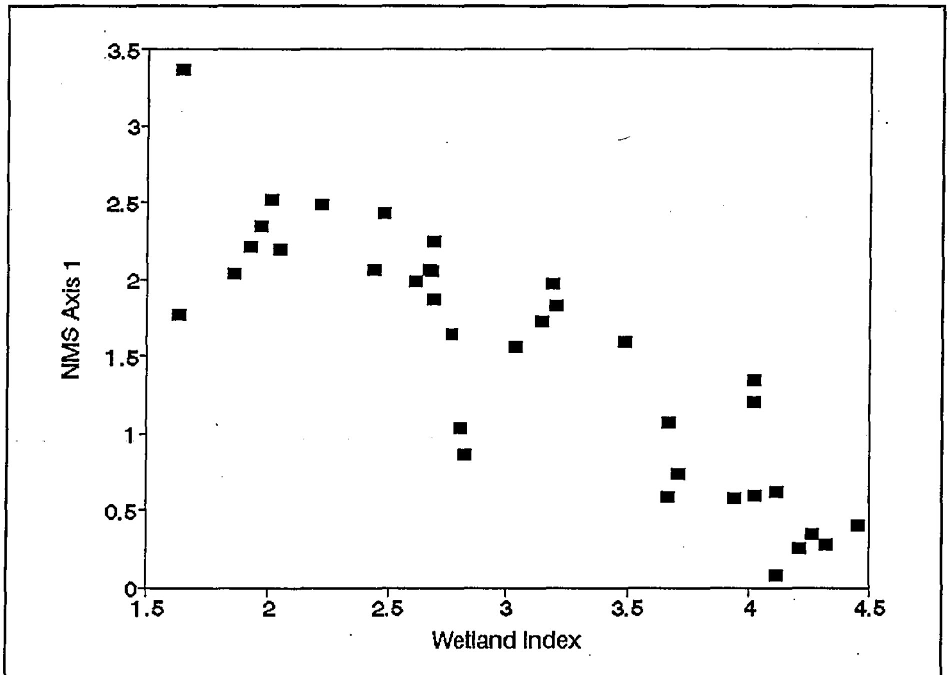

Figure 3. Correlation of NMS axis 1 scores with a frequency-weighted macroplot wetland index (Reed 1988, Wentworth et al. 1988) reflecting macroplot moisture status in the Willamette Floodplain RNA (r^2=0.76, SE=0.406).

lower-lying intermound macroplots tend to be moister, the moisture gradient increases primarily along the NMS axis 1 (X-axis). NMS ordination provides graphic support to an ecological interpretation (Kruskal 1964a, 1964b; Kenkel and Orloci 1986).

Analysis of the macroplot indirect moisture status confirmed distribution along a moisture gradient. This gradient is quantified by a wetness index based on weighted species frequency varying from 1.6 to 4.5. Average wetland index for intermound macroplots was 2.41, and for mound macroplots it was 3.82. Macroplot wetland index was positively correlated with NMS ordination axis 1 (r^2 = 0.76, SE=0.406) (Figure 3).

Correlation coefficients (r > 0.57) for species cover with the moisture index are shown in Table 4. *Rosa eglanteria*, the most dominant species found throughout all plots, showed slight affinity with decreased moisture (r = -0.22). Species with moderately strong positive correlations with the moisture gradient include *Carex unilateralis, Deschampsia cespitosa, Epilobium glandulosum, Juncus nevadensis, J. tenuis*, and *Plagiobothrys figuratus*. Species with moderately strong negative correlations include *Achillea millefolium, Carex tumulicola, Hypericum perforatum*, and *Poa pratensis*.

Table 4. Correlation coefficients (r) of selected species cover with NMS ordination axis 1 (moisture gradient) and NMS ordination axis 2 (burn effect gradient) for the Willamette Floodplain RNA.

Species	NMS Axis 1 (Moisture)	NMS Axis 2 (Burn Effect)
Achillea millefolium	-.69	.44
Beckmannia syzigachne	.58	-.26
Carex tumulicola	-.64	.36
Carex unilateralis	.66	-.54
Deschampsia cespitosa	.69	-.65
Epilobium glandulosum	.76	-.41
Galium triflorum	.25	-.58
Hordeum brachyantherum	.54	-.61
Hypericum perforatum *	-.91	.51
Juncus nevadensis	.65	-.68
Juncus tenuis	.71	-.50
Madia sativa	-.52	.74
Parentucellia viscosa *	-.10	.57
Plagiobothrys figuratus	.69	-.21
Poa pratensis *	-.68	.76
Veronica scutellata	.56	-.68

* alien species

Burn History Effects

In accord with our third objective, we examined the effect of historic burning on RNA vegetation. TWINSPAN yielded four macroplot groups (Table 2) at the second classification level. Macroplots in the most recently burned spaces (spaces 1 and 4) separate as two transitional groups (Groups A2 and B2).

NMS ordination axis 2 (Y-axis) is related to historic burning, negatively correlating (r = -0.51) with time since last burn (Figure 2). Macroplots in space 1 and space 4 that received more recent burning are positioned high in the ordination diagram. Again, we employed the MRPP to test for floristic differences between macroplots with respect to fire history (Table 5). Space 1, burned the year before vegetation sampling, differed significantly in species composition from the three other spaces collectively. Both space 2 and space 3 had not been burned in their entirety since the wildfire of 1979, and the MRPP test showed that Space 2 composition was not significantly different from that of Space 3.

In the mid 1980s, space 4 was burned in a complex fashion over 3 years. The MRPP test showed that space 4 composition differed from that of the other three spaces as a group at the 6% level of confidence (Table 5). In the MRPP test with space 2 and space 3 together (they do not differ significantly), space 4 differed at the 5% level of confidence. For space 4, which had not been burned for at least 5 years, historic burning still had a significant influence on species composition.

Table 4 also exhibits correlations of selected species with time since last burn. *Hypericum perforatum, Madia sativa, Parentucellia viscosa*, and *Poa pratensis* had moderately high positive correlations ($r \geq 0.50$) with the burn ordination axis, meaning they increased in cover with recency of burning. *Carex unilateralis, Deschampsia cespitosa, Hordeum brachyantherum, Juncus nevadensis, Juncus tenuis*, and *Veronica scutellata* had moderately strong negative correlations ($r \geq -0.60$) with the burn axis, meaning they decreased in cover with recency of burning.

We also examined the proportion of native versus introduced species for each space with respect to fire history. Space 1 averaged 46% native species based on macroplot frequency; space 2, 43%; space 3, 38%; and space 4, 38%. There was not much difference in the proportion of native species in the more recently burned spaces compared with the other spaces.

DISCUSSION

In 1990, the U.S. Fish and Wildlife Service proposed controlling the spread of rose and other invasive alien species and returning the wet prairie at the Willamette Floodplain Research Natural Area to its presettlement vegetative state by conducting periodic burns. A large area (space 1) in the northwest portion of the RNA was burned in September 1990 as first treatment of an area proposed for annual burning thereafter. Our study followed the 1990 burn and analyzed conditions 1 year after the initial annual burn. We defined three additional treatment areas (spaces 2, 3, and 4) based on fire history and future prescribed burning management.

Vegetation and Microtopography

Composition and structure of RNA vegetation recorded in our study are generally similar to those reported by Moir and Mika (1972) in an unpublished study. They described three plant communities related to microtopography: a hummocky *Deschampsia cespitosa* community occupying dark soil in low areas with few shrubs; a *Poa pratensis–Agrostis* spp. community at the margins of elevated mounds, with lighter soil and short-stature shrubs; and a dense shrubby *Rosa eglanteria* community on mounds.

With no concerted burning program in the years since 1972, the distinction between mound and intermound vegetation has blurred. The *Poa-Agrostis* community is no longer distinct, even in the same area sampled by Moir and Mika. Dominance of *Deschampsia cespitosa* in intermounds has diminished from 64% in 1972 to 33% in 1991. Apparently, Moir and Mika were describing vegetation reflecting recent intense grazing, which has since been terminated.

Although remnant wet prairies throughout the Willamette Valley are generally similar in their vegetation, studied tracts all differ in some respects from each other. Strong microtopographic patterns prevailing at the RNA are absent elsewhere. Rose Prairie and Fisher Butte sites, east of Fern Ridge Reservoir and 40 km south of Finley, support a *Deschampsia cespitosa* community, but other communities at these sites are not duplicated at the RNA (Pendergrass 1996). Likewise, Willow Creek Preserve in West Eugene supports rose-dominated communities similar to those of the RNA but includes several rare native species such as *Aster curtus, Erigeron decumbens*, and *Lomatium bradshawii* (Acker 1990; E.R. Alverson, field ecologist, The Nature Conservancy, Eugene Public Works Division Eugene, Ore., pers. com.).

At the Willamette Floodplain RNA, mounds and intermounds differ floristically, particularly with respect to dominance; yet several species are distributed ubiquitously in both habitats (e.g., *Agrostis tenuis, Holcus lanatus, Madia glomerata, Perideridia gairdneri*, and *Rosa eglanteria*). Topographic distinction is further supported by analysis of macroplot wetland index, an indirect floristic estimate of moisture conditions (Figure 3). In preparing wetland plant lists, the U.S. Fish and Wildlife Service relied on panels of experts and best professional judgment to determine the degree of wetland affinity of vascular plants. By employing a frequency-weighted index based on the wetland index of individual species, we accepted the subjective judgment of these panels. Short of field measurement of macroplot moisture conditions, this frequency-weighted index seemed to us a reasonable "measure" of wetness.

Fire History

We recognize two qualifications to our interpretation of burn effects. First, we relied on recent fire history—that is, number of times a given space was burned and

Table 5. MRPP tests of the strength of floristic differences between spaces and groups of spaces in the Willamette Floodplain RNA with different fire histories: space 1 last burned 1990, space 2 and space 3 last burned 1979, and space 4 burned 1985–87.

Space Combination Tested	MRPP Test[a]
Space 1 *vs.* 2, 3 & 4	T = -5.58, p = 0.0013
Space 1 *vs.* 2	T = -5.59, p = 0.0007
Space 1 *vs.* 3	T = -4.15, p = 0.0047
Space 1 *vs.* 4	T = -3.20, p = 0.0119
Space 2 *vs.* 3	T = -0.86, p = 0.15
Space 4 *vs.* 1, 2 & 3	T = -1.78, p = 0.062
Space 4 *vs.* 1	T = -3.20, p = 0.01
Space 4 *vs.* 2 & 3	T = -1.91, p = 0.05

[a] T = Kendall's coefficient of rank correlation, Tau

years since last burn. There was only a single prescription burn in space 1 the year prior to sampling. Interpretations should be more dependable in the future with a greater number of annual (space 1) and triennial (spaces 3 and 4) burns. Second, prescription burns covering areas of 40 ha or more are very patchy. Some areas do not burn, other areas burn intensely, and intermediate conditions between these extremes occur. Our sampling and analysis aggregated this heterogeneity and weakened our interpretation.

Based on the MRPP tests of the general floristic differences among spaces (Table 5), our study demonstrated that wet prairie species composition reflects fire history. The most recently burned space (space 1) is floristically distinctive from the other three spaces. Floristically, space 4, with a complex fire history and fairly recent fires (4–6 years), differs significantly from the other three spaces. There is no statistically significant difference in floristic composition between spaces 2 and space 3, which have not been burned for 12 years at present.

We further interpreted fire history effects by correlating species cover with ordination scores. NMS ordination axis 2 correlated with time since last burn. It surprised us that burning had a negative effect on abundance of *Deschampsia cespitosa, Hordeum brachyantherum, Juncus nevadensis*, and *Veronica scutellata* (Table 4)—all desired native species with wetland affinities. Since the prescribed burning program was just being initiated, we hesitate to give strong support to this interpretation.

Of the total flora of 94 species, 77% of alien species were negatively correlated with recency of burning and number of burns. *Rosa eglanteria* exhibited a slight negative correlation with burning, and though its cover did not diminish appreciably with burning, its stature was greatly reduced. These results agree, in part, with Pendergrass (1996), who reported inconsistencies in species responses to burning of wetland prairies near Fern Ridge Reservoir. In that study, some native annuals and perennials increased and others decreased in frequency with burning. *Deschampsia* frequency increased but cover declined significantly, "indicating a shift from fewer large plants to a greater number of smaller plants immediately following burning" (Pendergrass 1996). Pendergrass reported that after two burns total cover of exotic species increased in all but one community.

Based on our assessment of recent fire history, burning the RNA does not appear to be achieving the desired result of significantly reducing *Rosa eglanteria* cover and increasing native perennial herbaceous species cover. A longer term assessment of the prescribed burning program, however, is essential to making a more definitive judgment; this long-term program is underway.

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LITERATURE CITED

Acker, S.A. 1990. Monitoring *Deschampsia* grassland at the Willow Creek Preserve: an exploratory analysis of nested frequency data. Unpublished report to The Nature Conservancy, Portland, Oregon, Field Office.

Berry, K.J., K.L. Kvamme, and P.W. Mielke, Jr. 1980. A permutation technique for the spatial analysis of the distribution of artifacts into classes. American Antiquity 45:55-59.

Boag, P.G. 1992. Environment and Experience: Settlement Culture in Nineteenth-Century Oregon. University of California Press, Berkeley. 209 p.

Boyd, R. 1986. Strategies of Indian burning in the Willamette Valley. Canadian Journal of Anthropology 5:65-86.

Connelly, K.P. and J.B. Kauffman. 1991. Ecological effects of fire in Willamette Valley wetland prairies with special emphasis on *Lomatium bradshawii* and *Erigeron decumbens*, two rare endemic plants. Unpublished report prepared for The Nature Conservancy, Portland, Oregon, Field Office.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

Franklin, J.F. 1972. Willamette Floodplain Research Natural Area: grassland and Oregon ash forest on wet bottom lands in Oregon's Willamette Valley. *In* Federal Research Natural Areas in Oregon and Washington—A Guidebook for Scientists and Educators. Pacific Northwest Forest and Range Experiment Station, Portland, Ore.

Franklin, J.F. and C.T. Dyrness. 1988. Natural Vegetation of Oregon and Washington. Oregon State University Press, Corvallis. 452 p.

Habeck, J.R. 1961. The original vegetation of the mid-Willamette Valley, Oregon. Northwest Science 35:65-77.

Hill, M.O. 1979. TWINSPAN: a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, Ithaca, N.Y.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest: An Illustrated Manual. University of Washington Press, Seattle. 730 p.

Johannessen, C.L., W.A. Davenport, A. Millet, and S. McWilliams. 1971. The vegetation of the Willamette Valley. Annals of the Association of American Geographers 61:286-302.

Kenkel, N.C. and L. Orloci. 1986. Applying metric and nonmetric multidimensional scaling to ecological studies: some new results. Ecology 67:919-928.

Knezevich, C.A. 1975. Soil Survey of Benton County Area, Oregon. U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.

Kruskal, J.B. 1964a. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika 29:1-27.

Kruskal, J.B. 1964b. Nonmetric multidimensional scaling: a numerical method. Psychometrika 29:115-129.

McCune, B. 1991. Multivariate analysis on the PC-ORD system. Oregon State University, Corvallis.

Mielke, P.W., Jr., K.J. Berry, and E.S. Johnson. 1976. Multi-response permutation procedures for *a priori* classifications. Communications in Statistics: Communications and Methods A5(14):1409-1424.

Moir, W. and P. Mika. 1972. Prairie vegetation of the Willamette Valley, Benton Co., Oregon. Unpublished report on file at the Forest Science Laboratory Research Work Unit 1251, 3200 Jefferson Way, Corvallis, Ore.

The Nature Conservancy. 1989. Unofficial report of monitoring plan of *Lomatium bradshawii* at Willow Creek. Updated 1989 version. Unpublished report on file at The Nature Conservancy Field Office, Portland, Ore.

Pendergrass, K.L.(Connelly). 1996. Vegetation composition and response to fire of native Willamette Valley wetland prairies. Masters thesis, Oregon State University, Corvallis. 241 p.

Reed, P. B. 1988. National list of plant species that occur in wetlands: Oregon. Biological Report NERC-88/18.37, U.S. Fish and Wildlife Service, Washington, D.C.

Towle, J.C. 1982. Changing geography of Willamette Valley woodlands. The Oregon Historical Quarterly 83:67-87.

Wentworth, T.R., G.P. Johnson, and R.L. Kologiski. 1988. Designation of wetlands by weighted averages of vegetation data: a preliminary evaluation. Water Resources Bulletin 24:389-396.

Wilson, M.V., K.P. Connelly, and L.E. Lantz. 1993. Plant species, habitat, and site information for Fern Ridge Reservoir: a component of the project to develop management guidelines for native wetland communities. Unpublished report to Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi, and Soil Conservation Service, Portland, Oregon.

Wilson, M.V., D.E. Hibbs, and E.R. Alverson. 1991. Native plants, native ecosystems, and native landscapes. Kalmiopis 1:13-17.

Zimmerman, G.M., H. Goetz, and P.W. Mielke, Jr. 1985. Use of an improved statistical method for group comparisons to study effects of prairie fire. Ecology 66:606-611.