Final Report

Control of *Brachypodium sylvaticum* and Restoration of Rare Native Upland Prairie Habitat at Butterfly Meadows, Benton County ODA 1342 GR

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INTRODUCTION

Our project goal is to protect and restore rare Willamette Valley upland prairie habitat at Butterfly Meadows (Benton County) from invasion by the noxious weed *Brachypodium sylvaticum* (false brome).

Native prairies, which once dominated the landscape of the Willamette Valley, are considered among the rarest of Oregon's ecosystems and are in critical need of conservation. One of the largest remaining parcels of native upland prairie, Butterfly Meadows (Benton County), is being invaded by *Brachypodium sylvaticum.* This site is one of the three most important remaining habitats for the Fender's blue butterfly and Kincaid's lupine, listed as Endangered and Threatened respectively.

We propose to develop and implement herbicide treatments that control *Brachypodium sylvaticum* without harming native prairie vegetation. We will also develop and implement measures to reestablish native species from seed after removal of *Brachypodium sylvaticum*. Conifers and mature shrubs that have encroached on the meadow, both on the edge and in the complex, will be removed by mechanical means or girdling.

We propose to construct a buffer zone between the boundary of Butterfly Meadows and the neighboring intact forest and recently clear-cut areas, which are continuing sources of seed of *Brachypodium sylvaticum* invading Butterfly Meadows. This buffer zone will extend into both Starker Forest owned portions and OSU owned portions.

To determine the success of control of *Brachypodium sylvaticum* and woody species and restoration of native vegetation, we will monitor changes in abundance of *Brachypodium sylvaticum*, woody species, and native vegetation. We will use monitoring results to adjust future *Brachypodium sylvaticum* control measures and native vegetation restoration measures as needed.

This report describes the completion of the objectives applicable to phase one of this project:

Objective 2a Conduct pilot studies of herbicide control of *Brachypodium sylvaticum* and of potential adverse effects on native vegetation.

Objective 3 Conduct experimental studies of reestablishment of native species after removal of *Brachypodium sylvaticum*. Although objective 3 is part of phase two, scheduled for fall 2003, this report describes steps taken in preparation for its implementation in fall 2003 and spring 2004.

Objective 4 Remove encroaching woody species.

Objective 5a and 5b Construct buffer between Butterfly Meadows and source of *Brachypodium sylvaticum* propagules; Plant native species to replace *Brachypodium sylvaticum* in the buffer.

Objective 6c and 6d Monitor success of *Brachypodium sylvaticum* control in the buffer zone and the establishment of native species and adapt management strategies based on monitoring results; Monitor success of increasing abundance of Fender's blue butterfly adults

OBJECTIVE 2a *Conduct pilot studies of herbicide control of Brachypodium sylvaticum and of potential adverse effects on native vegetation*.

At the time that we received funding from ODA (fall 2002) we had not yet received the research permit from the USFW allowing us to spray within the boundaries of Butterfly Meadows. We conducted a pilot study outside the meadow boundaries, which is described in *Study A* of this report. As soon as we received the USFW permit, we conducted an additional study within the meadow boundaries, which is described in *Study B*. The results of these pilot studies will be used to design full experimental studies planned for the second phase of this project.

Pilot Study A

Methods

Study area Pilot study A was conducted on October 22, 2002 at an old meadow dominated by *Brachypodium sylvaticum* just outside the boundaries of Butterfly Meadows (Lat. 44° 36' 55.17″. Long: 123° 21' 7.33″). Although it was late in the fall season when we received funding from ODA, *Brachypodium sylvaticum* still had some green leaves at the base of the clumps, and the decision was made to go ahead with this initial study.

Experimental design

We used a randomized block design with three blocks containing each of the 8 treatments for a total of 24 treatments plots, which were about 3 m × 6 m with 1.5 m buffers between treatments (Figure 1). Wooden posts were placed in the center of the short sides of each plots and labeled with plot numbers. The long axis of the plots was oriented east and west (perpendicular to the slope) so that the herbicide operator could more easily maintain a steady walking speed necessary for proper application of herbicide rates.

Within each treatment plots, two vegetation measurements plots (1m × 1m) were randomly placed. A meter tape was stretched between the two wooden posts marking the center line of the treatment plots. When one faced uphill, the end-post to the right was designated 0 m, the one to the left was approximately 7 m. A meter buffer was established at each end of the treatment area. The remaining area was divided into ten 1 m quadrats. Quadrats 1-5 are read uphill of the tape, while quadrats 6-10 are downhill of the tape. Two of these 10 quadrats were randomly selected for vegetation measurement.

The herbicide treatments are described in Table 1. As part of the study design, a second Fusilade treatment at a reduced rate (0.05 lb a.i./acre) was applied to the Fusilade only plots on April 9, 2003. All of the treatments were sprayed with gas operated backpack sprayer and six nozzle spray boom at a rate of ten gallons of total spray mix per acre. Water was used as the carrier in all treatments. The field crew consisted of Matt Blakeley-Smith, Deborah Clark, Bruce Kelpsas, Fred Pfund, and Marc Vomocil.

Data collection
Before herbicide treatments were applied, abundance of *Brachypodium sylvaticum* was measured as percent cover in each measurement plot, along with any visually dominant species. Post-treatment measurements, which included abundance of *Brachypodium sylvaticum* mature plants and seedlings, conducted May 2003.

Data analysis
The responses of *Brachypodium sylvaticum* and native species as a group to treatments were examined with analysis of variance for replicated measurements. Rank transformations were applied to conform to statistical assumptions. Where the treatment effect was significant, individual treatments were compared using Tukey's HSD ($\alpha = 0.05$). Interaction of block and treatment were tested before examining treatment main effects.

Results and Discussion
Brachypodium sylvaticum was the most abundant plant species within plots. At 26% cover, it accounted for over half of the community cover in the post-treatment control plots (Table 2, Table 3). *Brachypodium sylvaticum* cover was also high in some of the post-treatment plots, indicating that some of the herbicide treatments were better at reducing *Brachypodium sylvaticum* cover than others.

The effects of herbicide treatment is seen more directly by looking at the proportional change in *Brachypodium sylvaticum* cover from October 2002, just before herbicide application, to May of 2003. The statistical effect of herbicide treatment was strong (Table 4). *Brachypodium sylvaticum* cover in control plots was essentially unchanged, but *Brachypodium sylvaticum* was reduced >90% in the treatments that contained the foliar herbicide glyphosate found in Accord: Accord, Accord + Plateau, Accord + Pendulum, and Oust + Accord (Table 3). Treatments that offered primarily soil uptake like Plateau (1) and Pendulum (3), although causing reduction in *Brachypodium* cover, were statistically indistinguishable from control (8).

Other species were too infrequent to test for their individual responses to herbicide application. To examine possible non-target herbicide effects, we grouped native prairie herb species for analysis. Native prairie herbs together averaged 7% cover in control plots (Table 3), and varied strongly across herbicide treatments. Although significant block and block×treatment effects make interpretation difficult (Table 5) the Accord + Plateau and Oust + Accord herbicide treatments seem to significantly reduce native plant herb cover (Table 3), even though the herbicide was applied when most of these plants were dormant. Perhaps the best combination of effective reduction of *Brachypodium sylvaticum* with no significant harm to native prairie herbs was the Fusilade herbicide treatment, which is a grass specific herbicide.

The rates used for these initial pilot studies were very conservative and were on the low end of the allowed label rates. The next steps should focus on investigating the effectiveness of higher rates in controlling mature *Brachypodium sylvaticum* clumps as well as the effective control of all non

native germinants. The goal is to find the ideal rate that maximizes control of *Brachypodium sylvaticum* while minimizing damage to native plants.

TP24	HT1	TP23	HT7	TP22	HT5				
TP21	HT3	TP20	HT8	TP19	HT2				
		TP18	HT4	TP17	HT6	TP16	HT2	TP15	HT5
				TP14	HT7	TP13	HT4	TP12	HT6
				TP11	HT1	TP10	HT3		
				TP9	HT8	TP8	HT2		
				TP7	HT6	TP6	HT7		
				TP5	HT3				
				TP3	HT4	TP4	HT1		
				TP2	HT5				
				TP1	HT 8				

Figure 1 Plot layout for pilot study A, which includes three replications for each of the eight herbicide treatments. TP = treatment plot number; HT = herbicide treatment number. Herbicide treatments are described in Table 1.

Table 1. Herbicide treatments and rates of applications applied fall 2002 for control of *Brachypodium sylvaticum* at Butterfly Meadows for pilot study A.

Herbicide treatment number	Herbicide treatment	Rate of herbicide application
1	Plateau and surfactant	0.188 lb a.e./acre and Activator 90 (0.5% v/v)
2	Fusilade and surfactant (repeated spring 2003)	fall:0.188lb a.i./acre and MSO (1% v/v) spring: 0.05 lb a.i./acre and MSO 2 lb a.i./acre)
3	Pendulum	2 lb a.i./acre
4	Accord and surfactant	2 lb a.i./acre and Activator 90 (0.5% v/v)
5	Accord and Plateau and surfactant	2 lb a.i./acre of Accord and 0.188 lb a.e./acre of Plateau and Activator 90 (0.5% v/v)
6	Accord and Pendulum and surfactant	2 lbs a.i./acre of Accord and 2 lb a.i./acre of Pendulum and Activator 90 (0.5% v/v)
7	Oust and Accord and surfactant	2.25 oz a.i./acre of Oust and 2 lbs a.i./acre of Accord and Activator 90 (0.5% v/v)
8	Control (no herbicide application)	

Table 2. Average cover (%) of measured taxa, other than *Brachypodium sylvaticum*, on May 1, 2003, after herbicide treatments applied October 22, 2002. P=native prairie herb; av = average; SE = standard error; n = 3 complete blocks.

		Treatments							
		Plateau	**Fusilade**	**Pendulum**	**Accord**	**Accord + Plateau**	**Accord + Pendulum**	**Oust + Accord**	**Control**
Achillea millefolium (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Brodiaea sp.(P)	av	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0
	SE	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Bromus carinatus (P)	av	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cardamine sp. (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex sp. (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cerastium arvense (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysanthemum leucanthemum	av	0.0	0.5	0.9	0.4	0.0	0.6	0.0	0.5
	SE	0.0	0.3	0.6	0.4	0.0	0.5	0.0	0.5
Cirsium arvense	av	3.8	0.3	1.3	2.5	0.0	3.0	0.0	0.0
	SE	2.4	0.3	0.7	2.3	0.0	3.0	0.0	0.0
Cirsium callilepis (P)	av	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.5
	SE	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.5
Corylus cornuta	av	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Crepis sp.	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynosurus echinatus	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dactylis glomerata	av	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.8

	SE	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Daucus carota	av	0.0	0.4	0.4	0.0	0.0	0.2	0.0	0.0
	SE	0.0	0.3	0.3	0.0	0.0	0.2	0.0	0.0
Epilobium paniculatum (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Eriophyllum lanatum (P)	av	0.2	1.0	1.8	0.2	0.0	0.2	0.0	2.4
	SE	0.2	0.5	1.4	0.2	0.0	0.2	0.0	2.3
Festuca arundinacea	av	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.8
	SE	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.8
Fragaria virginiana (P)	av	0.4	1.8	0.8	0.8	0.0	0.7	0.2	1.2
	SE	0.4	0.9	0.4	0.4	0.0	0.3	0.2	1.2
Galium aparine (P)	av	0.3	0.0	0.2	0.5	0.5	0.9	0.0	0.0
	SE	0.3	0.0	0.2	0.3	0.5	0.8	0.0	0.0
Geranium dissectum	av	0.0	4.0	0.2	0.0	0.0	0.0	0.0	0.7
	SE	0.0	2.8	0.2	0.0	0.0	0.0	0.0	0.4
Hypericum perforatum	av	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Juncus sp. (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus polyphyllus (P)	av	0.0	0.0	0.0	0.7	0.3	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.7	0.3	0.0	0.0	0.0
Lotus purshiana (P)	av	0.8	0.0	0.0	0.0	0.0	1.0	0.4	0.2
	SE	0.8	0.0	0.0	0.0	0.0	0.6	0.3	0.2
Madia sp. (P)	av	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Myosotis discolor	av	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Nemophila parviflora (P)	av	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0

Plantago major	av	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.5
	SE	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.5
Potentilla gracillis (P)	av	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2
	SE	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2
Prunella vulgaris (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Pseudotsuga menziesii	av	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
Pteridium aquilinum	av	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2
	SE	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2
Ranunculus occidentalis (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhamnus purshiana	av	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Rhus diversiloba	av	0.0	0.2	0.0	0.0	0.0	0.8	0.0	0.0
	SE	0.0	0.2	0.0	0.0	0.0	0.8	0.0	0.0
Rosa eglanteria	av	0.0	0.0	0.0	0.0	0.5	1.5	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.5	1.5	0.0	0.0
Rubus ursinus	av	0.3	0.0	0.3	0.0	1.7	0.0	0.2	0.0
	SE	0.3	0.0	0.3	0.0	1.2	0.0	0.2	0.0
Sanguisorba sp. (P)	av	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Sanicula crassicaulis (P)	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Sherardia arvensis	av	0.0	0.0	0.0	0.4	0.0	0.0	0.2	0.4
	SE	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.3
Sidalcea virgata (P)	av	0.0	0.8	0.7	0.0	0.0	0.0	0.0	0.5
	SE	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.5
Torilis arvensis	av	0.0	2.3	0.9	0.9	0.7	0.5	0.7	0.2

	SE	0.0	1.3	0.8	0.5	0.7	0.3	0.7	0.2
unknown 1	av	0.0	0.0	2.5	0.0	0.0	0.0	0.2	2.8
	SE	0.0	0.0	2.5	0.0	0.0	0.0	0.2	2.8
unknown 2	av	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
Veronica sp.	av	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	SE	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.3
Vicia americana (P)	av	0.5	0.8	0.2	0.4	0.2	0.3	0.2	0.7
	SE	0.5	0.2	0.2	0.3	0.2	0.2	0.2	0.4
Vulpia bromoides	av	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. Average cover (%) of mature *Brachypodium sylvaticum* plants before herbicide treatments (October 2002), average cover of *Brachypodium sylvaticum* mature plants and seedlings, relative cover, and proportional change after herbicide treatments (May 2003) and change of combined cover of native prairie herbs after herbicide treatments. Treatments sharing a letter are statistically indistinguishable. All data were ranked transformed for statistical analysis. n = 3 complete blocks. Av = average; SE = standard error

Treatments	*Brachypodium sylvaticum*									
	October 2002 Cover (%)		May 2003						Native prairie herbs (combined)	
			Cover (%)		Relative cover	Proportional change (0-1)		Seedling cover (%)		
	av	SE	av	SE		av	SE	av	SE	av	SE
Plateau	82.0	16.0	34.2d	5.8	0.73	-0.50cd	0.20	13.2	5.0	2.6abc	1.0
Fusilade	73.0	11.5	7.8bc	1.2	0.37	-0.88bc	0.04	14.5	3.5	5.1d	0.7
Pendulum	76.3	18.2	30.8d	5.8	0.70	-0.48cd	0.24	16.7	0.8	3.8bcd	1.6
Accord	85.0	8.8	2.7a	0.6	0.25	-0.97a	0.01	39.2	7.3	3.6bcd	1.1
Accord and Plateau	94.2	0.8	3.7ab	0.7	0.47	-0.96ab	0.01	37.2	12.4	1.3ab	0.4
Accord and Pendulum	73.3	10.9	3.2ab	1.2	0.23	-0.96ab	0.01	30.7	7.8	3.3cd	0.5
Oust and Accord	76.7	10.9	2.5a	0.9	0.53	-0.96ab	0.02	16.2	3.9	0.8a	0.3
Control (no herbicide)	50.5	25.5	25.8cd	4.6	0.62	-0.12d	0.46	13.5	3.3	7.1cd	2.9

Table 4. Analysis of variance of the proportional change in *Brachypodium sylvaticum* cover from October, 2002 (before herbicide treatment) to May, 2003. The response variable was rank-transformed before analysis. P is the probability of differences occurring between treatments just by chance.

	df	SS	MS	F	P
Block	2	240.8	120.4	2.38	0.11
Treatment	7	6875.5	982.2	19.38	0.00
Interaction	14	869.7	62.1	1.22	0.32
Residuals	24	1216.5	50.7		

Table 5. Analysis of variance of the combined cover of native prairie herbs. The response variable was rank-transformed before analysis. P is the probability of differences occurring between treatments just by chance.

	df	SS	MS	F	P
Block	2	125.1	62.5	1.11	0.35
Treatment	7	2948.7	421.2	7.44	<0.001
Interaction	14	4751.0	339.4	5.99	<0.001
Residuals	24	1359.3	56.5		

Pilot Study B

Methods

Study area Pilot study B was conducted on November 11, 2002 at the "lower" site of lupine concentration within the boundaries of Butterfly Meadows (Lat. 44° 36' 56.6″. Long: 123° 20' 53.76″).

Experimental design and data collection

Last summer lupines patches on Butterfly Meadows were located, marked, and mapped. Thirty-five of these plots (approximately $1m^2$) were randomly assigned one of 7 herbicide treatments (5 replications/treatment) (Table 6). The plots were marked with color-coded flagging, surveyor flags labeled with plot number, and metal stakes with labeled tags with plot number (Table 6). Applications of herbicides were made using a single flat fan spray tip at ten gallons of spray mix per acre over plot. Post-treatment data measuring presence of *Lupinus sulphureus* var. *kincaidii*, cover of *Brachypodium sylvaticum* mature plants and seedlings and Fender's blue butterfly larvae were conducted May 2003.

Data analysis

The responses of Kincaid's lupine, Fender's blue butterfly larvae, and *Brachypodium sylvaticum* to herbicide treatments were examined with one-way analysis for variance. Transformations were applied to conform to statistical assumptions. Where the treatment effect was significant, individual treatments were compared using Tukey's HSD ($\alpha = 0.05$).

Results and discussion

Treatments that had a significant effect on *Brachypodium sylvaticum* cover were those that relied primarily on foliar uptake of the herbicide like Accord and Fusilade. Herbicide treatments had a significant effect on *Brachypodium sylvaticum* cover. Accord + Pendulum and Accord + Plateau were most effective, reducing *Brachypodium sylvaticum* to less than one-tenth its cover in control plots (Table 7). Pendulum and Plateau alone were indistinguishable from controls indicating that the Accord tank-mix partner provided most o the control even under the late-season timing. The cover of *Brachypodium* seedlings was not significantly affected by the herbicide treatments including Pendulum and Plateau, which should have provided some soil residual effect. Rates of these materials may not have been adequate to provide any long lasting control. .

Despite the strong mortality of *Brachypodium sylvaticum* in several herbicide treatments, no treatment caused a significant decline in the number of Kincaid's lupine leaves or the number of Fender's blue butterfly larvae (Table 7). In fact, there is some evidence that *Brachypodium sylvaticum* control can stimulate the production of Kincaid's lupine leaves. Perhaps the best balance of *Brachypodium sylvaticum* reduction and favoring lupine leaves and butterfly larvae was the Fusilade treatment. Fusilade reduced *Brachypodium sylvaticum* to 9% cover, in contrast to 31% cover in control plots. There were 70% more lupine leaves compared with the control plots and larva numbers were highest in Fusilade plots.

Table 6. Herbicide treatments and rates of applications applied in fall 2002 for control of *Brachypodium sylvaticum* at Butterfly Meadows (pilot study B).

Treatment	Rate of herbicide application	Flagging	Plot numbers
1. Accord and surfactant	2 lb a.i./acre + Activator 90 (0.5% v/v)	blue/white stripe	7, 26, 33, 22, 18
2. Fusilade and surfactant	0.188 lb a.i./acre and MSO (1% v/v)	red/black stripe	5, 9, 6, 20, 29
3. Pendulum	2 lb a.i./acre	hot pink	34, 21, 30, 14, 24
4. Plateau and surfactant	0.188 lb a.e./acre +Activator 90 (0.5% v/v)	blue	12, 25, 4, 15, 28
5. Accord and Plateau and surfactant	2 lb a.i./acre of Accord and 0.188 lb a.e./acre of Plateau and Activator 90 (0.5% v/v)	yellow stripe	16, 3, 13, 31, 27
6. Accord and Pendulum and surfactant	2 lbs a.i./acre of Accord and 2 lb a.i./acre of Pendulum and Activator 90 (0.5% v/v)	red	1, 2, 11, 35, 23
7. Control (no herbicide)		yellow	8, 19, 32, 10, 17

Table 7. Average responses of Kincaid's lupine, Fender's blue butterfly larvae, and *Brachypodium sylvaticum* to herbicide treatments. n = 5. av = average; SE = standard error. P is the probably that differences between treatments occurred just by chance.

Treatment	Lupine leaf number		Larvae		*Brachypodium sylvaticum* adult cover		*Brachypodium sylvaticum* seedling cover	
	av	SE	av	SE	av	SE	av	SE
Accord + Pendulum	39.4	7.0	1.0	0.3	1.8a	0.9	1.2	1.0
Accord + Plateau	72.8	12.6	1.6	0.2	2.5a	1.0	3.0	1.8
Accord	63.4	19.3	1.8	0.6	7.2ab	3.2	6.8	2.5
Fusilade	80.6	26.9	2.2	0.6	9.0ab	4.6	5.0	2.1
Pendulum	57.4	16.1	1.6	0.6	28.0b	6.6	4.6	1.6
Plateau	54.2	28.9	1.4	0.7	31.6b	9.3	1.4	0.5
control	47.6	9.6	1.6	0.5	31.0b	9.9	1.5	0.3
F	0.82^{r}		0.49		5.99^{s}		1.90^{r}	
P	0.56		0.81		<0.01		0.12	

r: analyzed after rank transformation; s: analyzed after arcsine square-root transformation

OBJECTIVE 3 *Conduct experimental studies of reestablishment native species after removal of Brachypodium sylvaticum.*

Although Objective 3 is part of phase two of the project (scheduled for fall 2003), initial preparatory steps were taken in phase one. A draft study plan to investigate methods for reestablishing native species after removal of *Brachypodium sylvaticum* by herbicides was developed (see below).

An additional component of using transplants of native species started from seed in conjunction with field sowed seeds was added to the study plan after field observations showed that after herbicide spraying very thick litter layers were formed from the dead *Brachypodium sylvaticum*. Transplants may be more successful in revegetation than plants establishing from seed.

Seeds of native species 20 species, including nectar plants, were purchased for both the sowing and the transplants. Seeds for the transplants have been planted by Susan Morré, Oregon State University graduate student, using greenhouse space donated by Robin Rose, Oregon State University, and will be ready for transplanting in the fall 2003.

Study Plan
Promoting Seed Regeneration of Native Plant Species
Butterfly Meadows Project
Draft

Goal

Promote the re-establishment of native herbaceous plant species after removal of the noxious weed *Brachypodium sylvaticum* with herbicides in a native upland native prairie at Butterfly Meadows, Benton County.

Objective

Determine the effectiveness of manipulated field conditions in promoting the regeneration of target native herbaceous species from seed and the survival of seedling transplants of these species in a native upland prairie at Butterfly Meadows.

Experimental design

Experimental plots (randomized block design, n = 3) had been previously established at Butterfly Meadows to determine the effectiveness of different herbicide treatments on control of *Brachypodium sylvaticum* at Butterfly Meadows (see Objective 2a, Study A for details). The herbicide treatment showing the best control of *Brachypodium sylvaticum* without harm to native plant species or the endangered Fender's blue butterfly will be used for this study.

Within this treatment new plots will be established, which will be manipulated to minimize mortality and maximize germination and growth of seedlings. Proposed treatments include the following. Final selection will depend on availability of resources.

- Litter removal
- Application of fungicide to seeds
- Depth of seed burial
- Season of sowing
- Sow seeds into buried pots of potting soil
- Sequence of sowing
- Mixtures of sowed seeds and transplants

In fall 2003 seeds will be sowed and seedlings transplanted into these plots. The following spring the establishment rate of the seeds and the survival rate of the transplants will be measured. Response variables, establishment rate of seeds and survival rate of transplants, will be compared among treatments and with each other using analysis of variance. Future long-term measurements will be made depending on availability of funding

OBJECTIVE 4 *Remove encroaching woody species*.

Removal of encroaching woody species were originally scheduled for spring 2003 and fall 2004, but during assessment of the priority areas for woody removal, it was realized that these areas woody plants were generally encroaching lupine populations and the associated endangered species, Fender's blue butterfly. Paul Hammond (expert on Fender's blue butterfly) recommended that all the tree removal be postponed until later in the season (late summer to fall) to avoid interference with the butterfly larvae and the adult butterflies. Work will also need to be scheduled around any restrictions during fire season.

OBJECTIVE 5a *Construct buffer between Butterfly Meadows and source of Brachypodium sylvaticum.*

The *Brachypodium sylvaticum* in the buffer area managed by Oregon State University was sprayed earlier than anticipated (see Interim report) on May 29 with 1.75% Accord and 5% Velpar mixture over two acres using a backpack sprayer. Great care was taken during the operation and was conducted under favorable wind, temperature and humidity conditions.

Starker Forests marked out the boundary (50 foot buffer) on the land that they managed in early June. They postponed the herbicide spraying until the after the flight season of Fender's blue and should be treating it within the next few weeks.

OBJECTIVE 5b *Plant native species to replace Brachypodium sylvaticum in the buffer.*

After reconsidering the effectiveness of herbicides after only one year in controlling *Brachypodium sylvaticum*, the decision was made to postpone the reseeding of the buffer area. The consensus was that it may take more than one year of herbicide spraying to control the *Brachypodium sylvaticum* and rather than risk wasting resources on re-seeding it was suggested to spray multiple years to insure control of *Brachypodium sylvaticum.* With permission from Tim Butler (ODA), we redirected the money budgeted for seed to growing out transplants that would be compared to seed sowing in the experimental study on native plant restoration (See Objective 3).

OBJECTIVE 6c *Monitor success of Brachypodium sylvaticum control in the buffer zone and the establishment of native species and adapt management strategies based on monitoring results***.**

A plan for monitoring abundance for *Brachypodium sylvaticum* in the buffer zone was developed (see below) and will implemented late summer 2003. A plan for monitoring native species will be developed after the buffer zone is reseeded with native species.

Monitoring Plan for *Brachypodium sylvaticum* in Butterfly Meadows Boundary

Management objective
Limit the cover of *Brachypodium sylvaticum* to 10% cover in the boundary area of Butterfly Meadows, Benton County (T.11S., R.5W.,Sec.18, S1/2 of NW1/4) in any year between 2003 and 2005.

Management response
If the cover of *Brachypodium sylvaticum* is above the threshold of 10%, then herbicide application will be reapplied the (assuming that resources are available to do so) with additional annual monitoring. If the cover of *Brachypodium sylvaticum* is equal or below the threshold of 10%, then no management actions will be taken and the population will be monitored in two years. Note that if any part of the confidence interval has crossed the threshold, then management action will take place.

Management treatment design and implementation
See protocol for design and implementation from Debbie Johnson (Oregon State University) and Fred Pfund (Starker Forests) for spraying the boundary area with herbicides.

Monitoring design
Sampling objective
Be 95% confident that cover estimates are within 10% of the estimated true value.

Sampling design
Constraints of time and money make it impractical to sample the entire boundary area. So three to five circular macroplots 15-20 m diameter in the boundary area along Butterfly Meadows will be subjectively selected. Although these "key areas" will be representative of the entire boundary area that is being encroached by false brome, we cannot make statistically inferences from these macroplots to the entire area. However, management actions will be taken based on the monitoring results from each of the key areas.

Within these key areas 5-10 permanent sampling plots ($1m^2$ diameter) will be located a random distance and random direction from a post centrally placed in the macroplot. These $1m^2$ diameter plots will be marked with a stake located in the middle of the plot. Cover of false brome will be measured. Plot locations will be listed in Appendix A.

Field measurements
See Appendix B for detailed field procedures and Appendix C for sample data sheet.

Monitoring timing

Monitoring will initially be conducted in late summer annually for two years beginning in 2003. If cover values remain below the threshold without continued herbicide treatments, monitoring will done every other year, assuming resources are available.

Data analysis

An estimate of the population abundance of false brome will be determined for each of the key areas by calculating the average cover (%) along with a 95% confidence level. The average cover and confidence interval will be compared to the to the management objective to determine if it has been met and if management action is needed.

Monitoring implementation and evaluation of results

1. Collect field data at specified intervals. Ensure that data sheets are completely filled out, duplicated and stored in safe place.
2. Analyze data after each measurement cycle.
3. Complete a summary report that includes recommendations for management responses. Also evaluate field methods, costs, sample size, and relevancy of the monitoring project.
4. After the last monitoring period (2005), prepare a final monitoring report and distribute to all interested parties, including publishing or sharing at technical forum.

Resources for monitoring

1. See Appendix B necessary equipment and personnel for data collection.
2. Personnel responsible for implementing monitoring for 2003:

Monitoring tasks	**Facilitators**
Set up monitoring plots	Deborah Clark (OSU) Debbie Johnson (OSU) Susan Morré (OSU)
Collect field data	Deborah Clark (OSU) Debbie Johnson (OSU) Susan Morré (OSU)
Analyze field data and evaluate results	Deborah Clark (OSU) Debbie Johnson (OSU) Susan Morré (OSU)
Write and distribute summary report	Deborah Clark (OSU) Debbie Johnson (OSU) Susan Morré (OSU)

The monitoring plan includes three attachments, which are not included in this report.

1. Attachment A *Monitoring Plot Locations* Includes directions, maps and aerial photographs describing the study location, and the location of permanent sampling units
2. Attachment B *Field Procedures* Includes field procedures, including necessary equipment and personnel
3. Attachment C *Sample Data sheet*

OBJECTIVE 6d *Monitor success of increasing abundance of Fender's blue butterfly adults.*

Paul Hammond conducted a survey of Fender's blue butterfly *Icaricia icarioides fenderi* during the flight season, June 3 and 11, at Butterfly Meadows. He reports that habitat in section SE1 has deteriorated badly for the Fender's blue butterfly due to shading by Douglas-fir trees, which are probably promoting growth of false brome. Butterfly habitat is also deteriorating in NE2 section also due to the heavy encroachment of young Douglas-fir, false brome, and bracken fern. His final report on butterfly counts is pending.