



AN ABSTRACT OF THE THESIS OF

Whitney Goodell for the degree of Honors Baccalaureate of Science in Environmental Science presented on November 20, 2007. Title: Invasion of *Brachypodium sylvaticum* in prairie and forest habitats: differences in community structure between uninvaded and invaded systems in Bald Hill Park, Corvallis, Oregon.

Abstract approved: \_\_\_\_\_  
Patricia Muir

*Brachypodium sylvaticum* (Huds.) Beauv. is an invasive grass that can be found in forest and prairie communities throughout the Willamette Valley, Oregon. It can out-compete native species of grasses and forbs and become dominant in a broad range of habitats. This study investigated if there were differences in vegetation structure between communities that were not invaded by *B. sylvaticum* and communities that were invaded. The study took place in Bald Hill Park, Corvallis, Oregon, and prairie and forest habitats were analyzed separately. Percent cover of *B. sylvaticum* and eight other vegetation or substrate types were used to assess community structure. Prairie habitats showed considerable differences in vegetation structure, particularly in cover of grasses (other than *B. sylvaticum*), forbs, and bare ground. *Brachypodium sylvaticum* can decrease quality of forage for wildlife, or displace endemic species of plants, some of which are endangered. Control of the invasive grass is important for the survival of endangered plant or insect species. At the levels of invasion in this study, forest habitats did not show much change in community structure, which was surprising. The lack of detectable differences may be due to small sample size or insufficient levels of invasion of *B. sylvaticum*.

**Key words:** *Brachypodium sylvaticum*, invasive plant species, vegetation structure

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Invasion of *Brachypodium sylvaticum* in prairie and forest habitats:  
differences in community structure between uninvaded and invaded systems  
in Bald Hill Park, Corvallis, Oregon

by  
Whitney Goodell

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

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Whitney Goodell, Author

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## **Invasion of *Brachypodium sylvaticum* in prairie and forest habitats: differences in community structure between uninvaded and invaded systems in Bald Hill Park, Corvallis, Oregon**

### INTRODUCTION

*Brachypodium sylvaticum* (Huds.) Beauv., or slender false-brome, is a non-native invasive perennial grass that has the potential to spread throughout forested areas in the Pacific Northwest and California (Blakeley-Smith and Kaye 2006). It was originally cultivated in North America for ornamental purposes, but the first record of *B. sylvaticum* as an escaped invader was in 1939 near Eugene, Oregon (Chambers 1966; Hitchcock et al. 1969). By 1966, there were at least two large, well-established colonies near Corvallis, Oregon, and in the past few decades it has spread in the Willamette Valley and into the Cascade foothills of Oregon (Nature Conservancy 2002).

*Brachypodium sylvaticum* can become dominant in forested and in open prairie habitats. It can invade sites with a variety of aspects and light conditions, and can grow at elevations of up to 1050 m (Kaye 2001a; Blakeley-Smith and Kaye 2006). *Brachypodium sylvaticum*'s broad amplitude of environmental tolerance means that it impacts a wide scope of ecological functions, niches, and species. For instance, this invasive grass can alter forest development by competing for water, nutrients, and light, thus inhibiting the establishment of tree seedlings (Blakeley-Smith and Kaye 2006). *Brachypodium sylvaticum* may also supersede threatened or endangered prairie species, such as Willamette daisy (*Erigeron decumbens* Nutt. var. *decumbens*), golden paintbrush (*Castilleja levisecta* Greenm.), and Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*

[C.P. Smith] L. Phillips), which is a host plant for the endangered Fender's blue butterfly (*Icaricia icariodes fenderi* [Lycaenidae]) (Kaye 2001a). Change in species composition and vegetation structure of a community can alter habitat for small mammals, insects, reptiles, songbirds, and other wildlife (Blakeley-Smith and Kaye 2006).

This study investigated whether there was a difference in vegetation composition in prairie or forest communities that had been invaded by *B. sylvaticum* as compared to uninvaded but otherwise similar communities. If there are differences in vegetation composition and structure between uninvaded and invaded prairies, it seemed likely that these would involve decreases in percent cover of grass (other than *B. sylvaticum*), forbs, and bare ground in invaded communities. If *B. sylvaticum* invades forest communities and competes for water and nutrients, then it would be likely that tree cover (specifically seedlings and saplings), bare ground, forbs, and mosses would have lower cover in invaded plots. If any of these scenarios were the case, wildlife and ecosystem functions would be impacted, and the specific implications of these impacts would depend on which components of the community were most drastically altered, and to what extent.

This was an observational study as invasion of *B. sylvaticum* was not a controlled, administered treatment, simply a natural occurrence that was observed. This places some limitations on the ability to determine cause and effect in community structure. Observed differences in structure were presumed to be caused by the presence and invasion of *B. sylvaticum*, but it should be noted that observed differences may have been due to other factors.

## METHODS

### *Study Area*

This study was conducted on September 10<sup>th</sup> and 26<sup>th</sup>, 2007 in Bald Hill Park in Corvallis, OR. Bald Hill is located on the west side of Corvallis, at 44.568°N, 123.335°W. The park is 115 ha in size and has a summit of 230 m. All study sites were located on the northwest side of Bald Hill, in upland prairies that stretched off the east side of a dirt park trail that ran along the base of the hill (Fig. 1). Several multi-modal paths run along the base of the hill, and there are multiple dirt paths around the hill leading up to the summit. Community types located within the park include upland prairies, forests, oak savannah, riparian areas, and wetlands. The forested areas were dominated by Douglas fir [*Pseudotsuga menziesii* (Mirbel) Franco] and Oregon white oak (*Quercus garryana* Dougl. ex Hook.) (Corvallis Parks & Rec. 2007).

### *Species*

*Brachypodium sylvaticum* is a tufted perennial grass native to Europe, Asia and North Africa. It grows 50-70 cm tall and has flat leaves that are 4-10 mm wide. The leaves are pilose (bearing soft, spreading hairs), open-sheathed at the base, and do not have auricles. The flowers, 7 to 13 in count, are on spikelets with pedicels that are short or lacking. The short pedicels are referenced in the genus epithet *Brachypodium*, which is derived from the Greek *brachys*, short, and *podion*, foot. The awns are straight, 10-15 mm long, and the lemmas are strongly ciliate and 2-nerved (Hitchcock et. al 1969).

*Brachypodium sylvaticum* reproduces rapidly from seed. It is reportedly not rhizomatous, but it does form large clumps that coalesce, and it can resprout from small stem or root fragments when cut (Kaye 2001a; Nature Conservancy 2002). European biologists report that *B. sylvaticum* does not maintain a persistent (>1 year) seed bank, but this has not been confirmed for North American populations of the species (Blakeley-Smith and Kaye 2006).

*Brachypodium sylvaticum*'s common name, false-brome, refers to the frequent misidentification of *B. sylvaticum* as a brome grass (genus *Bromus*) (Nature Conservancy 2002). *Brachypodium sylvaticum* can be distinguished from *Bromus* species by its open leaf sheaths and the short or absent pedicels of the spikelets. *Bromus* species have sheaths closed for greater than ¼ of their length and their spikelets are on long pedicels (Kaye 2001a). Another distinctive feature of *B. sylvaticum* is its bright green color that lasts long into late autumn and early winter (Kaye 2001a).

### *Field Methods*

Four transects were sampled in Bald Hill Park (Fig. 1). Each transect passed through four plant community types: uninvaded prairie, invaded prairie, invaded forest, and uninvaded forest, with invasion referring to that of *B. sylvaticum*. For this study, an “uninvaded” community supported  $\leq 5\%$  cover of *B. sylvaticum*. To be considered a “community,” the conditions (invaded/ uninvaded, prairie/ forest) had to extend a minimum of 10 m along a transect. Transects were 65 to 110 m in length, depending on the depth of each community along the transect.

Transect location was determined by finding sites in which all four communities fell along a straight line; when that occurred, that transect was used in the study. Each of the four transects originated in one of two upland prairies, two transects in each prairie (Fig. 1). From the prairie, transects extended uphill into forested areas.

Along each transect, eight 1 x 1 m square plots were sampled, with two plots in each community. The plots were centered on the transect line, and the locations of plots within each community were chosen using a random number generator. The length of each community along each transect was measured, and two random distances were chosen within the given range.

Within the meter-square plots, data on vegetation structure were collected. Percent cover of *B. sylvaticum* and eight other functional groups was estimated for each plot. Functional groups were grasses (other than *B. sylvaticum*), forbs, shrubs, ferns, mosses, litter, trees, and bare ground. Percent cover of trees was quantified as the ground area occupied by boles, or stems in the case of seedlings and saplings. Cover of trees did not refer to canopy cover.



**Figure 1.** Four transect locations in Bald Hill Park, Corvallis, OR. Each transect originated in one of two prairies on the northwest side of the park.

### *Data Analysis*

Two plots within the same community along the same transect were not independent samples, so data from each pair of plots were averaged. Data for forest communities were analyzed separately from those for prairie communities because the vegetation structures of the two were so different. *Brachypodium sylvaticum* may impact the two habitats differently and thus the habitats should be analyzed separately. The same set of analyses was carried out for each habitat, using Minitab Statistical Software. Non-

parametric tests were used for all analyses because the sample size of the study was small ( $n = 4$ ), and it cannot be assumed that the data were normally distributed.

Box plots for each variable (vegetation or substrate type) were used to compare visually the median and range of percent cover in uninvaded and invaded communities. Strong overlap of the ranges indicated that there was little difference in percent cover of that variable between uninvaded and invaded communities. Little or no overlap of the ranges suggested that *B. sylvaticum* invasion had caused changes in percent cover.

Mann-Whitney U tests (non-parametric tests) were run for each variable to determine if there was a difference in median percent covers of the given variable between invaded and uninvaded communities. P-values of  $\leq 0.05$  indicated that there was strong evidence to suggest that the median percent cover in an uninvaded community was not equal to the median percent cover in an invaded community. Given the small sample size of this study, p-values of  $\leq 0.1$  were considered indicators of likely statistical significance.

Scatter plots provided a visual representation of the relationship between percent cover of a given variable and cover of *B. sylvaticum*. The plotted points were cover values averaged across pairs of plots from each community in each transect. Spearman's rank correlation coefficients were calculated to quantify the strength and direction of the relationships.

Scatter plots, box plots, and Mann-Whitney U tests were used to analyze change in percent cover of each variable individually. Pie charts were used to represent changes in vegetation structure of the community as a whole. "Slices" in the pie chart represent proportional cover of each variable, calculated as mean percent cover for a given variable

divided by the sum of all mean covers for the habitat as a whole. The slices did not represent the actual average percent cover values, as these could add up to > 100% due to layering of organic material. Pie charts provided a visual representation of community structure and variation between uninvaded and invaded communities.



## RESULTS

### *Prairie*

Cover of several functional groups in prairie systems differed considerably between uninvaded and invaded communities. Cover of grass (excluding *B. sylvaticum*) and bare ground was higher in uninvaded than in invaded prairies, with no overlap of ranges of cover for either between the two site types (Fig. 2a). Forb cover also tended to be higher in uninvaded than in invaded prairies, with little overlap of cover between types. Respective differences in cover of grass, bare ground, and forbs between uninvaded and invaded plots were statistically significant, as determined by Mann-Whitney U tests ( $p \leq 0.1$ ; Table 1a). Shrubs also had a statistically significant difference in cover between site types, and showed no overlap of ranges of cover, although this had a different trend: percent cover of shrubs was higher in invaded prairie than in uninvaded prairie. Trees and ferns were excluded from the analysis of prairie vegetation structure. Trees never occurred in the prairie plots, and ferns occurred in only one plot, accounting for 2% cover.

Cover of grass (excluding *B. sylvaticum*), bare ground, and forbs showed strong negative correlation with cover of *B. sylvaticum* (Fig. 3a-c). Proportionately, grass made up a much smaller amount of cover in invaded communities than it did in uninvaded communities (Fig. 5a). Bare ground and forbs also had proportionally more cover in uninvaded sites, consistent with the results based on absolute cover.

### *Forest*

Forest systems did not show much difference in composition and structure between uninvaded and invaded communities. The only variable to show a significant difference in percent cover was litter, which tended to be more abundant in uninvaded than invaded sites (Fig. 2b;  $p = 0.061$  adjusted for ties; Table 1b). There was a strong negative correlation between cover of litter and cover of *B. sylvaticum* (Fig. 4). Proportional cover of litter was considerably less in invaded forest than in uninvaded forest (Fig. 5b). All other variables showed very little difference in proportional cover between the two communities (Table 1b; Fig. 2b; Fig. 5b).

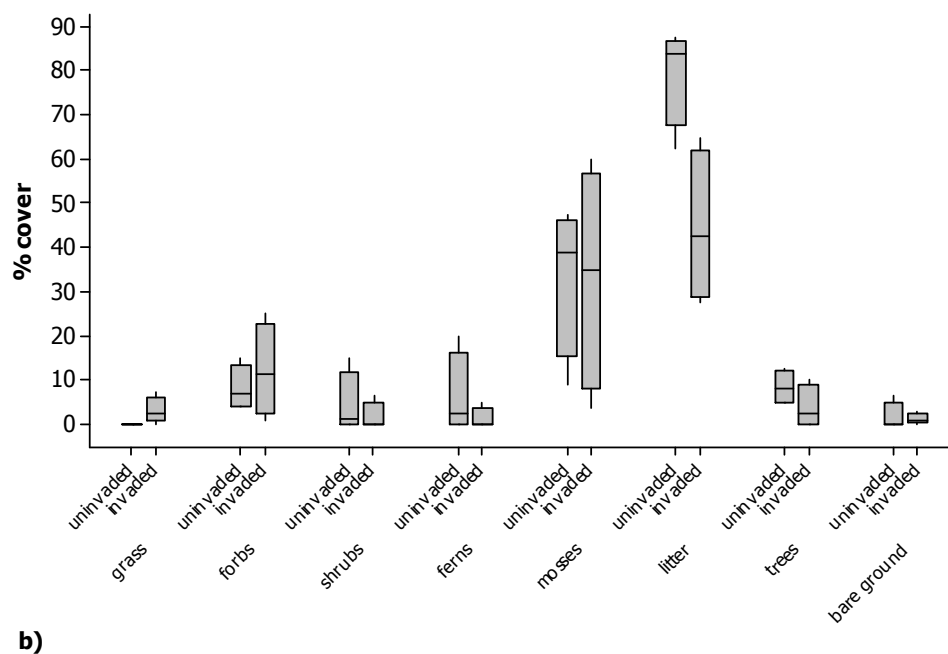
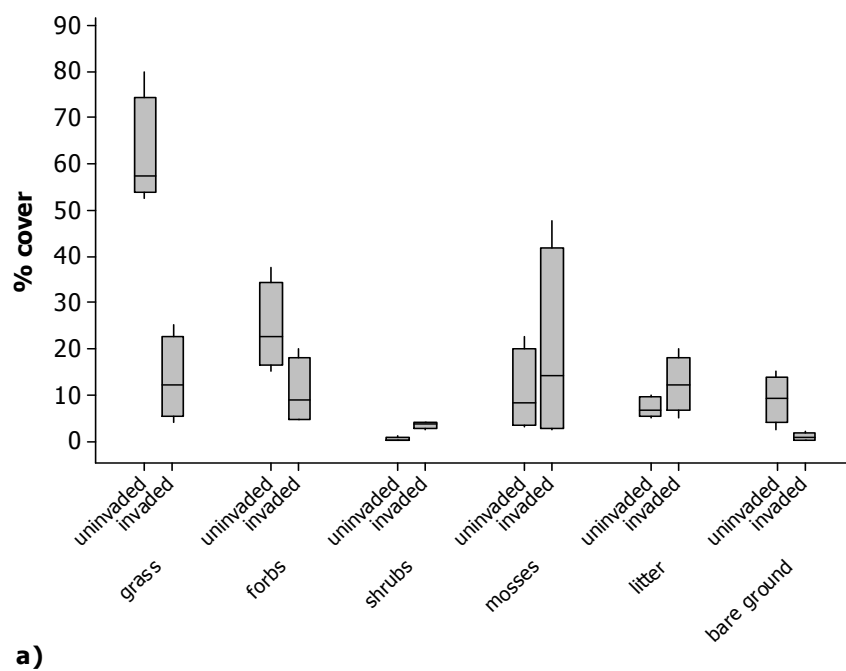
**Table 1.** Mann-Whitney U test results [test statistics (W=) and p-values] for each vegetation or substrate type.  $H_0$ : median cover in uninvaded community = median cover in invaded community. **a)** Prairie community; trees and ferns were excluded from analysis. **b)** Forest community; Mann-Whitney U test could not be carried out for grass, as the median cover for uninvaded plots = 0.

**a) Prairie**

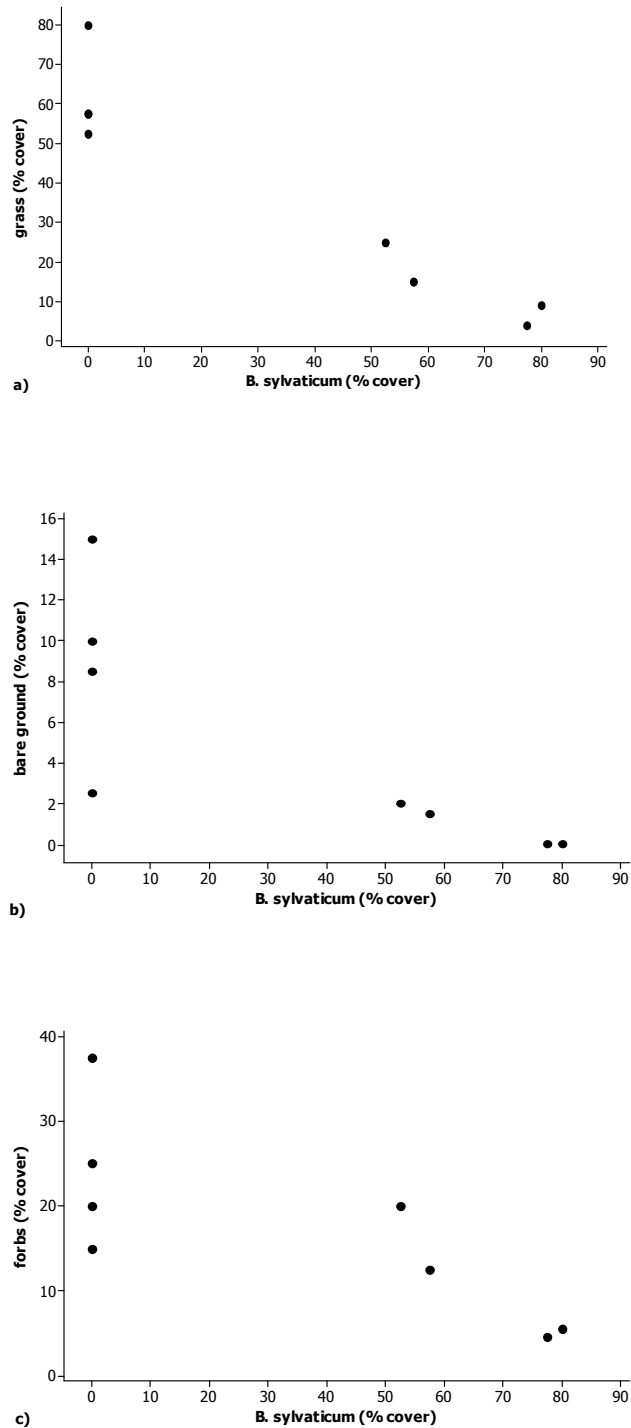
| <b>Variable</b> | <b>Test statistic (W=)</b> | <b>p-value</b>            |
|-----------------|----------------------------|---------------------------|
| Grass           | 10.0                       | 0.030 (adjusted for ties) |
| Forbs           | 11.5                       | 0.081 (adjusted for ties) |
| Shrubs          | 26.0                       | 0.026 (adjusted for ties) |
| Mosses          | 19.0                       | 0.885                     |
| Litter          | 22.5                       | 0.245 (adjusted for ties) |
| Bare ground     | 10.0                       | 0.029 (adjusted for ties) |

**b) Forest**

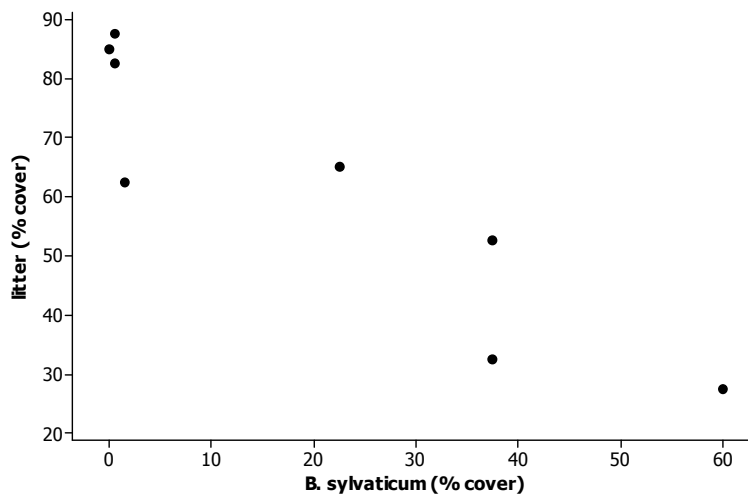
| <b>Variable</b> | <b>Test statistic (W=)</b> | <b>p-value</b>            |
|-----------------|----------------------------|---------------------------|
| Forbs           | 19.5                       | 0.772 (adjusted for ties) |
| Shrubs          | 16.0                       | 0.620 (adjusted for ties) |
| Ferns           | 15.5                       | 0.505 (adjusted for ties) |
| Mosses          | 18.5                       | 1.000 (adjusted for ties) |
| Litter          | 11.0                       | 0.061                     |
| Trees           | 13.0                       | 0.180 (adjusted for ties) |
| Bare ground     | 20.5                       | 0.536 (adjusted for ties) |



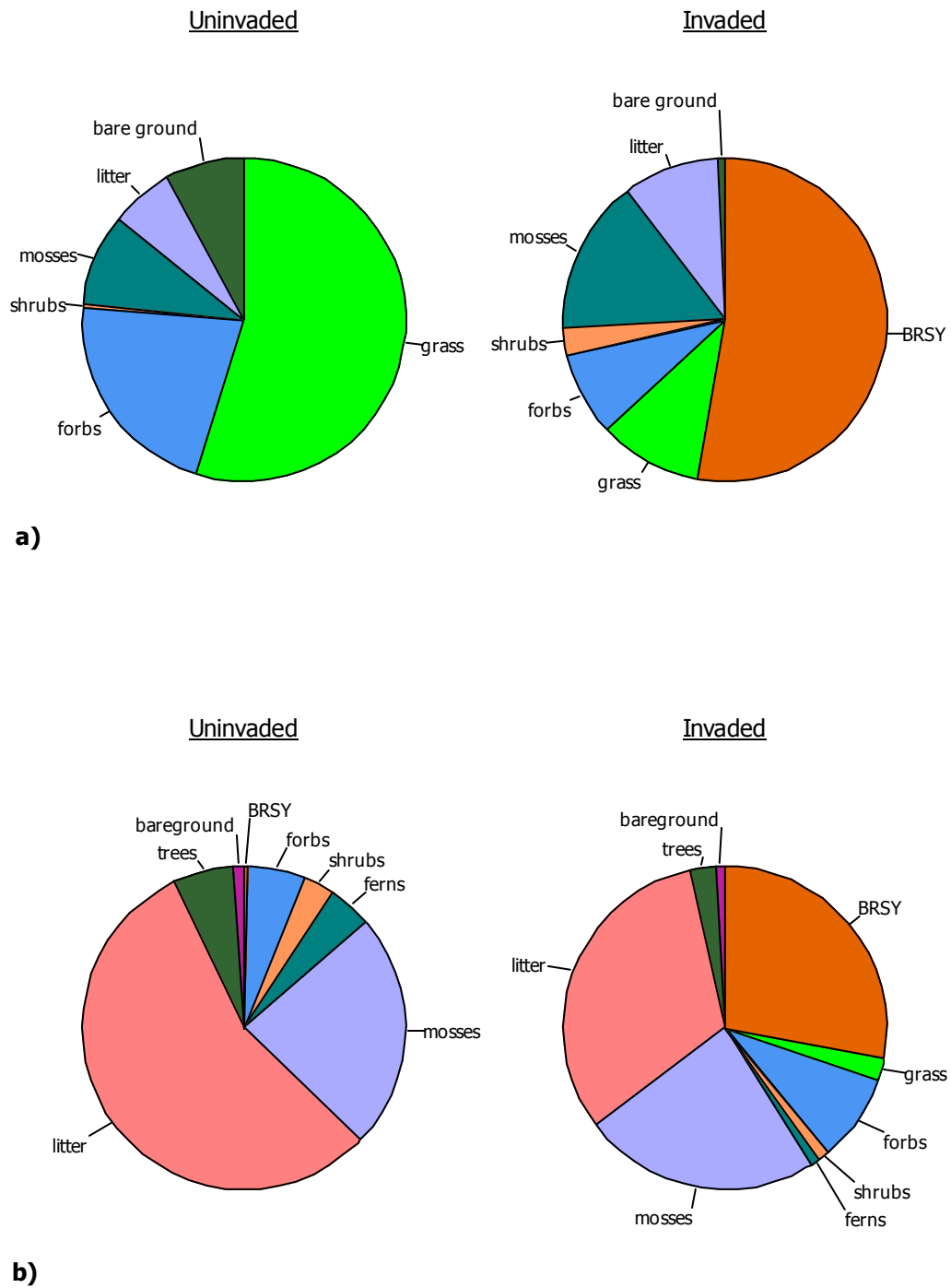
**Figure 2.** Ranges and medians of percent cover of variables in uninverted plots vs. inverted plots. Line mid-box = median, top of box = upper quartile, bottom of box = lower quartile, end of whiskers = minimum and maximum values (range). Note: grass cover excludes *B. sylvaticum*. **a)** Prairie communities; trees and ferns were excluded from analysis. **b)** Forest communities.



**Figure 3.** Relationships of cover of vegetation or substrate type to cover of *B. sylvaticum* in prairie systems. Points represent average cover values across pairs of plots from each community type in each transect. **a)** Grass cover vs. *B. sylvaticum*; Spearman's  $r = -0.952$ . **b)** Bare ground cover vs. *B. sylvaticum*; Spearman's  $r = -0.790$ . **c)** Forb cover vs. *B. sylvaticum*; Spearman's  $r = -0.763$ .



**Figure 4.** Relationship of litter to cover of *B. sylvaticum* in forest systems. Points represent average cover values across pairs of plots from each community type in each transect. Spearman's  $r = -0.915$ .



**Figure 5.** Community structure – mean proportional cover of variables in uninvaded plots vs. invaded plots. BRSY = *Brachypodium sylvaticum*. **a)** Prairie community structure. **b)** Forest community structure.

## DISCUSSION

### *Prairie*

In prairie habitats, there appeared to be a difference in vegetation structure between communities that had not been invaded by *B. sylvaticum* and communities that had been invaded. Several variables showed a negative correlation with percent cover of *B. sylvaticum*, particularly grass (other than *B. sylvaticum*), bare ground, and forbs. The shift in composition of prairie communities invaded by *B. sylvaticum* probably modifies ecosystem processes and interactions.

The results for prairie communities were consistent with expectations. In a community invaded by *B. sylvaticum*, other grasses seemed to be displaced by the invasive grass, which also seemed to invade much of the bare ground in the community. This latter effect may further propagate the former, as germination of grass seed may be reduced when there is less bare ground and thus less contact between seeds and the soil substrate. Modifications of vegetation structure, particularly the reduction in percent cover of grasses and forbs, can impact food sources for wildlife. *Brachypodium sylvaticum* appears to be unpalatable to wildlife, although there may be some late-season browsing by deer (Nature Conservancy 2002). Given *B. sylvaticum*'s ability to create monotypic stands, this can mean large expanses of prairie lacking in forage for wildlife. Reduction in forage quality impacts wildlife as well as grazing livestock (False-brome 2003).

The invasion of *B. sylvaticum* in prairie systems and the associated decrease in cover of forbs has grim implications for the success of threatened and endangered plant



and wildlife species. *Brachypodium sylvaticum* can displace the federally listed threatened Kincaid's lupine (*Lupinus sulphureus* subsp. *kincaidii*), an obligate larval host of the federally listed endangered Fender's blue butterfly (*Icaricia icariodes fenderi*) (Kaye and Thorpe 2006). The invasive grass can also displace the endemic prairie plant Willamette daisy (*Erigeron decumbens* spp. *decumbens*), which is listed by the USFWS and Oregon Department of Agriculture as an endangered species (Thorpe and Kaye 2006). Golden paintbrush (*Castilleja levisecta*) used to occupy Willamette Valley prairies, but is now considered to be extirpated in Oregon (Kaye 2001b). Invasion of *B. sylvaticum* could thwart efforts to reintroduce golden paintbrush in Oregon prairies. Populations of BLM Bureau Sensitive Species such as wayside aster (*Eucephalus vialis*), thinleaf pea (*Lathyrus holochlorus*), meadow checkerbloom (*Sidalcea campestris*), and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) occur in the Willamette Valley, but are threatened by invasion of *B. sylvaticum* (Blakeley-Smith and Kaye 2006). Dense patches of *B. sylvaticum* can also stifle efforts to restore fish habitat. Trees planted to provide shade and structure in riparian areas may struggle to establish if competing with *B. sylvaticum* for space and nutrients (False-brome 2003).

Aside from decreasing forage quality for wildlife, displacing endangered plant and insect species, and inhibiting riparian restoration endeavors, *B. sylvaticum* invasion has implications for fire danger and subsequently the ecological succession of the community. Thick cover of *B. sylvaticum* can alter fire regimes, increasing risk and rate of spread of wildfire as a heavy layer of thatch can increase fine one-hour fuel loads (Nature Conservancy 2002).

### *Forest*

Forest habitats did not show much difference in vegetation structure between communities that had not been invaded by *B. sylvaticum* and communities that had been invaded. With the exception of litter, none of the variables showed a strong relationship, positive or negative, with percent cover of *B. sylvaticum*. In forest habitats invaded by *B. sylvaticum* at the level of invasion found in my study sites, shifts in community structure were not detected.

These results are a bit surprising as it was expected that invasion of *B. sylvaticum* would be associated with a reduction of seedling and sapling cover, as it competes for water, nutrients and light (Blakeley-Smith and Kaye 2006). This may be explained by time passed since invasion. If invasion occurred relatively recently, there may have been insufficient time for reductions in saplings to be apparent. This represents a disadvantage of a retrospective study; time and rate of invasion was not necessarily known, as it was not a prescribed treatment.

It should be noted that delayed reduction in cover applies to saplings, but not seedlings. Seedlings are, by definition, in their first year of growth, so effects of *B. sylvaticum* should be apparent in the first season. However, few seedlings were observed in uninvaded forests in this study. With so few seedlings in uninvaded plots, it may be difficult to detect differences in cover between uninvaded and invaded forests. A larger sample size may be necessary to detect such differences. Sample size is discussed further in “Problems, suggested improvements.”

Lack of detected shifts in community structure may be due to relatively modest cover of *B. sylvaticum* in invaded forest plots. Invaded forest had an average cover of *B.*

*sylvaticum* of 40%, considerably lower than 67% cover in invaded prairie (Fig. 3; Fig. 4). It is possible that the level of invasion in forest sites was not high enough for noticeable differences in community structure to occur.

It was interesting that litter was the only variable to show notable decrease in percent cover in invaded forests. It would seem that if vegetation structure were similar between uninvaded and invaded sites, litter cover would also stay fairly consistent.

In prairie communities, grass and bare ground showed considerable reductions in percent cover between uninvaded and invaded plots. However, these variables had such low percent cover (in the case of grass, 0%) in uninvaded forest plots that it could be difficult, or impossible, for a reduction in cover to occur.

### *Control*

Control of *B. sylvaticum* has not been studied extensively (Nature Conservancy 2002). The first line of defense is the prevention of spread itself. In general, spread is caused by vehicles, logging equipment, ATV's, animals and humans (Blakely-Smith and Kaye 2006). Machinery used in forest management should be cleaned, and forest workers and recreationists should clean their boots, clothes, bikes, and equipment upon exiting an infested area (False-brome 2003). Roadside patches are a significant source of seed, and vehicles may pick up seeds and disperse them further down the road (False-brome 2003). Removal of these patches may help slow invasion in nearby communities.

In Europe, *B. sylvaticum* was not present in heavily grazed areas, indicating that recurring disturbance such as grazing or mowing may reduce or eradicate the species (Nature Conservancy 2002). Manual removal of the plant may work for small

infestations, but this is neither labor nor time-efficient for large infestations. Proper removal must include the entire root system to prevent resprouting (Nature Conservancy 2002). Burning does not appear to be effective in reducing *B. sylvaticum*, although it may improve the efficiency of follow-up chemical treatments, as the plant produces new shoots after fire, which are more likely to be affected and killed by herbicides (Nature Conservancy 2002). Herbicide treatment is currently the most effective method for control and eradication. Hexazinone (tradename Velpar®) and glyphosphate formulations (tradenames Accord®, RoundUp®) have provided control in Oregon State University Research Forests (Nature Conservancy 2002).

All of these herbicides are broad-spectrum treatments that are used on broadleaf and grass species, as well as woody brush and trees (Dow 2002; Monsanto 2005; E.I. duPont 2006). Due to the nature of broad-spectrum herbicides, applications of these chemicals over large infestations of *B. sylvaticum* can have wide-ranging implications for non-target plant and animal species. While effective in controlling *B. sylvaticum*, herbicides should be used with caution, and effects of treatments on non-target species within the community should be monitored.

#### *Problems, suggested improvements*

It should be emphasized that this was an observational study. Results were drawn from uninvaded and invaded communities that were not sampled prior to invasion. While discrepancies in vegetation composition and community structure were presumed to be due to *B. sylvaticum*, cause and effect cannot be determined with certainty. Conclusions on correlations between cover of variables and cover of *B. sylvaticum* could be

legitimately reached, but inference about causation is limited. Conclusions that ascribe differences in community structure between uninvaded and invaded habitats to presence of *B. sylvaticum* were based on the presupposition that all other factors in the communities remained similar. This assumption allows for the possibility that differences in composition between uninvaded and invaded habitats were not, in fact, due to the presence of *B. sylvaticum*, but rather to other causes unaccounted for in this study. Future studies could test for cause and effect by starting with stable uninvaded communities, prescribing *B. sylvaticum* introductions, and monitoring differences over time. This would allow for greater validity in inferred results.

The small sample size ( $n = 4$  plots per community type) and the restricted geographic range of this study should not be overlooked. The consequences of these conditions are limited statistical power and conclusions that can only be drawn for one location (i.e. Bald Hill Park), although they might also apply to other communities. Initially, it was intended that this study would include sample transects in MacDonald Forest, Corvallis, Oregon. This failed, however, as uninvaded plots of prairie and forest habitats contiguous with invaded plots could not be found in the time available for reconnaissance. This was the limiting factor for number of transects in Bald Hill Park, as well.

It was observed that the few areas of uninvaded forest in the park seemed to have greater tree density and canopy cover than did invaded forest areas. I did not collect data on canopy cover or tree density, but it would be interesting for future studies to examine whether and how canopy cover and tree density are correlated with ground cover of *B. sylvaticum* in forest habitats.

## *Conclusions*

In this study, prairie habitats exhibited altered vegetation structure between communities invaded by *B. sylvaticum* and communities that were not invaded by *B. sylvaticum*. Invasion of *B. sylvaticum* into prairie communities was associated with decreased bare ground, which is important for seed germination of native forbs and grasses. Invasion may displace already-fragile populations of many endangered or threatened plant or insect species. *Brachypodium sylvaticum*'s impact on community structure, endangered species, and fire danger makes it a nuisance, even a threat, in prairie ecosystems, and effective control methods should be sought and applied wherever feasible.

Forest systems did not show the same differences in habitat structure between communities invaded by *B. sylvaticum* and communities that were not invaded by *B. sylvaticum*. In the range of *B. sylvaticum* cover found in my forested sites, it seemed that *B. sylvaticum* had limited ecological impact with regard to vegetation structure in forest systems. However, control of the invasive grass should not be considered futile, as control in forest ecosystems may help reduce the spread of *B. sylvaticum* into prairies, where it had noted impact.

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APPENDIX A



Compiled data of percent cover of *B. sylvaticum* and each variable. Values are the average of pairs of plots in each community type in each transect. Unshaded rows are prairie plots, shaded rows are forest plots.

| Transect | Community | BRSY | grass | forbs | shrubs | ferns | mosses | litter | trees | bare ground |
|----------|-----------|------|-------|-------|--------|-------|--------|--------|-------|-------------|
| 1        | UninvPrar | 0    | 52.5  | 37.5  | 1      | 0     | 3      | 6      | 0     | 8.5         |
| 1        | InvPrar   | 57.5 | 15    | 12.5  | 3.5    | 0     | 3.5    | 11.5   | 0     | 1.5         |
| 1        | InvFor    | 37.5 | 7.5   | 15    | 0      | 0     | 60     | 32.5   | 5     | 1           |
| 1        | UninvFor  | 0    | 0     | 15    | 0      | 0     | 47.5   | 85     | 12.5  | 0           |
| 2        | UninvPrar | 0    | 57.5  | 20    | 0      | 0     | 4      | 5      | 0     | 15          |
| 2        | InvPrar   | 52.5 | 25    | 20    | 4      | 0     | 2.5    | 5      | 0     | 2           |
| 2        | InvFor    | 60   | 2.5   | 7.5   | 6.5    | 0     | 3.5    | 27.5   | 0     | 1           |
| 2        | UninvFor  | 1.5  | 0     | 8.5   | 0      | 20    | 9      | 62.5   | 5     | 6.5         |
| 3        | UninvPrar | 0    | 57.5  | 25    | 0      | 0     | 12.5   | 10     | 0     | 10          |
| 3        | InvPrar   | 77.5 | 4     | 4.5   | 4      | 1.5   | 47.5   | 20     | 0     | 0           |
| 3        | InvFor    | 22.5 | 2.5   | 25    | 0      | 5     | 47.5   | 65     | 0     | 0           |
| 3        | UninvFor  | 0.5  | 0     | 5     | 15     | 0     | 35     | 87.5   | 5     | 0           |
| 4        | UninvPrar | 0    | 80    | 15    | 0      | 0     | 22.5   | 7.5    | 0     | 2.5         |
| 4        | InvPrar   | 80   | 9     | 5.5   | 2.5    | 0     | 25     | 12.5   | 0     | 0           |
| 4        | InvFor    | 37.5 | 0     | 1     | 0      | 0     | 22.5   | 52.5   | 10    | 3           |
| 4        | UninvFor  | 0.5  | 0     | 4     | 2.5    | 5     | 42.5   | 82.5   | 11    | 0           |

## APPENDIX B

Field data sheets by transect and community type. UP = uninvaded prairie, IP = invaded prairie, IF = invaded forest, UF = uninvaded forest. The plots were located along the transect from the start of that community type, at the number of paces indicated.

| <b>Transect 1</b> | <b>% cover</b> |                 | <b>Comments</b>  |
|-------------------|----------------|-----------------|--|
| <b>UP</b>         | <b>5 paces</b> | <b>9 paces</b>  |  |
| BrSy              | 0              | 0               | 1-20 paces<br>(range indicates the extent<br>[length] of the community type) |
| grass             | 35             | 70              |  |
| forbs             | 50             | 25              |  |
| shrubs            | 2              | 0               |  |
| ferns             | 0              | 0               |  |
| mosses            | 2              | 4               |  |
| litter            | 5              | 7               |  |
| trees             | 0              | 0               |  |
| bare ground       | 15             | 2               |  |
| <b>IP</b>         | <b>4 paces</b> | <b>7 paces</b>  |  |
| BrSy              | 80             | 35              | 1-10 paces   |
| grass             | 10             | 20              |  |
| forbs             | 10             | 15              |  |
| shrubs            | 0              | 7               |  |
| ferns             | 0              | 0               |  |
| mosses            | 2              | 5               |  |
| litter            | 8              | 15              |  |
| trees             | 0              | 0               |  |
| bare ground       | 0              | 3               |  |
| <b>IF</b>         | <b>7 paces</b> | <b>15 paces</b> |  |
| BrSy              | 45             | 30              | 1-20 paces   |
| grass             | 15             | 0               |  |
| forbs             | 25             | 5               |  |
| shrubs            | 0              | 0               |  |
| ferns             | 0              | 0               |  |
| mosses            | 40             | 80              |  |
| litter            | 20             | 45              |  |
| trees             | 0              | 10              |  |
| bare ground       | 0              | 2               |  |
| <b>UF</b>         | <b>5 paces</b> | <b>11 paces</b> |  |
| BrSy              | 0              | 0               | 1-15 paces   |
| grass             | 0              | 0               |  |
| forbs             | 10             | 20              |  |
| shrubs            | 0              | 0               |  |
| ferns             | 0              | 0               |  |
| mosses            | 20             | 75              |  |
| litter            | 85             | 85              |  |
| trees             | 15             | 10              |  |
| bare ground       | 0              | 0               |  |

| <b>Transect 2</b> | <b>% cover</b>  |                 | <b>Comments</b> |
|-------------------|-----------------|-----------------|-----------------|
| <b>UP</b>         | <b>5 paces</b>  | <b>13 paces</b> |                 |
| BrSy              | 0               | 0               | 1-15 paces      |
| grass             | 50              | 65              |                 |
| forbs             | 15              | 25              |                 |
| shrubs            | 0               | 0               |                 |
| ferns             | 0               | 0               |                 |
| mosses            | 5               | 3               |                 |
| litter            | 5               | 5               |                 |
| trees             | 0               | 0               |                 |
| bare ground       | 25              | 5               |                 |
| <b>IP</b>         | <b>1 paces</b>  | <b>9 paces</b>  |                 |
| BrSy              | 35              | 70              | 1-20 paces      |
| grass             | 35              | 15              |                 |
| forbs             | 25              | 15              |                 |
| shrubs            | 5               | 3               |                 |
| ferns             | 0               | 0               |                 |
| mosses            | 0               | 5               |                 |
| litter            | 3               | 7               |                 |
| trees             | 0               | 0               |                 |
| bare ground       | 2               | 2               |                 |
| <b>IF</b>         | <b>5 paces</b>  | <b>13 paces</b> |                 |
| BrSy              | 65              | 55              | 1-20 paces      |
| grass             | 0               | 5               |                 |
| forbs             | 15              | 0               |                 |
| shrubs            | 3               | 10              |                 |
| ferns             | 0               | 0               |                 |
| mosses            | 7               | 0               |                 |
| litter            | 20              | 35              |                 |
| trees             | 0               | 0               |                 |
| bare ground       | 0               | 2               |                 |
| <b>UF</b>         | <b>11 paces</b> | <b>15 paces</b> |                 |
| BrSy              | 3               | 0               | 1-15 paces      |
| grass             | 0               | 0               |                 |
| forbs             | 15              | 2               |                 |
| shrubs            | 0               | 0               |                 |
| ferns             | 15              | 25              |                 |
| mosses            | 15              | 3               |                 |
| litter            | 60              | 65              |                 |
| trees             | 0               | 10              |                 |
| bare ground       | 3               | 10              |                 |

| <b>Transect 3</b> | <b>% cover</b> |                 | <b>Comments</b> |
|-------------------|----------------|-----------------|-----------------|
| <b>UP</b>         | <b>7 paces</b> | <b>19 paces</b> |                 |
| BrSy              | 0              | 0               | 1-20 paces      |
| grass             | 50             | 65              |                 |
| forbs             | 25             | 25              |                 |
| shrubs            | 0              | 0               |                 |
| ferns             | 0              | 0               |                 |
| mosses            | 15             | 10              |                 |
| litter            | 10             | 10              |                 |
| trees             | 0              | 0               |                 |
| bare ground       | 20             | 0               |                 |
| <b>IP</b>         | <b>5 paces</b> | <b>11 paces</b> |                 |
| BrSy              | 90             | 65              | 1-15 paces      |
| grass             | 5              | 3               |                 |
| forbs             | 2              | 7               |                 |
| shrubs            | 2              | 6               |                 |
| ferns             | 1              | 2               |                 |
| mosses            | 70             | 25              |                 |
| litter            | 20             | 20              |                 |
| trees             | 0              | 0               |                 |
| bare ground       | 0              | 0               |                 |
| <b>IF</b>         | <b>5 paces</b> | <b>38 paces</b> |                 |
| BrSy              | 25             | 20              | 1-40 paces      |
| grass             | 0              | 5               |                 |
| forbs             | 20             | 30              |                 |
| shrubs            | 0              | 0               |                 |
| ferns             | 0              | 10              |                 |
| mosses            | 35             | 60              |                 |
| litter            | 60             | 70              |                 |
| trees             | 0              | 0               |                 |
| bare ground       | 0              | 0               |                 |
| <b>UF</b>         | <b>7 paces</b> | <b>13 paces</b> |                 |
| BrSy              | 0              | 1               |                 |
| grass             | 0              | 0               |                 |
| forbs             | 8              | 2               |                 |
| shrubs            | 5              | 25              |                 |
| ferns             | 0              | 0               |                 |
| mosses            | 20             | 50              |                 |
| litter            | 90             | 85              |                 |
| trees             | 10             | 0               |                 |
| bare ground       | 0              | 0               |                 |

| <b>Transect 4</b> | <b>% cover</b>  |                 | <b>Comments</b> |
|-------------------|-----------------|-----------------|-----------------|
| <b>UP</b>         | <b>5 paces</b>  | <b>14 paces</b> |                 |
| BrSy              | 0               | 0               | 1-30 paces      |
| grass             | 75              | 85              |                 |
| forbs             | 20              | 10              |                 |
| shrubs            | 0               | 0               |                 |
| ferns             | 0               | 0               |                 |
| mosses            | 35              | 10              |                 |
| litter            | 5               | 10              |                 |
| trees             | 0               | 0               |                 |
| bare ground       | 5               | 0               |                 |
| <b>IP</b>         | <b>13 paces</b> | <b>21 paces</b> |                 |
| BrSy              | 65              | 95              | 1-25 paces      |
| grass             | 15              | 3               |                 |
| forbs             | 7               | 4               |                 |
| shrubs            | 5               | 0               |                 |
| ferns             | 0               | 0               |                 |
| mosses            | 35              | 15              |                 |
| litter            | 20              | 5               |                 |
| trees             | 0               | 0               |                 |
| bare ground       | 0               | 0               |                 |
| <b>IF</b>         | <b>20 paces</b> | <b>25 paces</b> |                 |
| BrSy              | 40              | 35              | 1-40 paces      |
| grass             | 0               | 0               |                 |
| forbs             | 0               | 2               |                 |
| shrubs            | 0               | 0               |                 |
| ferns             | 0               | 0               |                 |
| mosses            | 25              | 20              |                 |
| litter            | 25              | 80              |                 |
| trees             | 20              | 0               |                 |
| bare ground       | 0               | 6               |                 |
| <b>UF</b>         | <b>6 paces</b>  | <b>13 paces</b> |                 |
| BrSy              | 1               | 0               | 1-15 paces      |
| grass             | 0               | 0               |                 |
| forbs             | 5               | 3               |                 |
| shrubs            | 5               | 0               |                 |
| ferns             | 0               | 10              |                 |
| mosses            | 20              | 65              |                 |
| litter            | 85              | 80              |                 |
| trees             | 10              | 12              |                 |
| bare ground       | 0               | 0               |                 |

