# Analysis of Forb Community Composition as a Function of Distance from the 

 Forest Edge in a Montane Meadow of the Central Oregon Cascades
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Meadow site at H.J. Andrews Experimental Forest, Photo: Ruth Mares


#### Abstract

Tree invasion into subalpine meadows has been noted in the Oregon Cascades (e.g. Franklin et. al 1971). The meadow surveyed on Frissell Ridge in the H.J. Andrews Experimental Forest in the Central Oregon Cascades is no exception. Encroachment of trees into meadow communities poses a threat to forb species that cannot survive under dense canopy cover. To examine forb community changes from forest to meadow, line transects were established at seven sites, pointing towards the center of the meadow from individual trees. I present quantitative data that describes variance in species richness, dominance, and similarity in forb communities as a function of distance from the forest edge. Species richness increased with distance from the edge, while dominance decreased with distance. The slow but steady encroachment of trees into this meadow will probably decrease species richness and abundance in important forb communities.


## Introduction

In the Central Oregon Cascades, montane meadows are an important and iconic feature of the landscape. Wildflowers blanket the steep meadows and benefit the ecosystem with biological diversity and rich resources for pollinator communities (Kearns et. al 1998). In a study conducted on the North Rim of the Grand Canyon National Park, researchers found that meadow openings can generate four to five times the herbaceous production and plant richness as the surrounding forest (Moore \& Deiter 1992). As forests invade these crucial and yet fragile environments, the meadow plant community will likely change. Trees that become successfully established in a meadow pose a threat to meadow communities that are susceptible to being shaded out, as well as providing habitats suitable for further seedling establishment (Magee \& Antos 1992). Forests adjacent to this meadow have been burned $\sim 10$ times, over the past 400 years (Frederick J.

Swanson, Figure 10), providing disturbances that are crucial for the establishment and success of meadow species, as well as removal of forest species (Magee \& Antos 1992). Without disturbances such as these, trees are able to establish themselves and alter the environment to be unsuitable for meadow species. Providing information quantifying plant community in this
environment is important to raise concern of these fragile ecosystems that provide so much for surrounding communities. Quantitative data on diversity and dominance as a function of distance from the forest edge provide an image of what we can expect to see if these meadows are further invaded.

In this study I aim to describe the herbaceous plant community within a small montane meadow( $\sim 3.5 \mathrm{ha}$ ) as a function of distance from the forest edge. I will address two questions regarding meadow plant community composition:

1) How does the forb plant community vary with distance from trees?
2) How do richness and dominance of the forb plant community vary as a function of distance from trees?

I expect that forb species richness and abundance will increase with distance from the forest understory. Without trees present, more light and water will be available for meadow species, as large trees intercept a majority of rainfall as well as photosynthetically active radiation (PAR) that is usable for these herbaceous plants to photosynthesize. Herbaceous species that are shade tolerant are likely to be dominant under the canopy, while shade intolerant meadow species are likely to be dominant in the open meadow.

## Study Area

This study was conducted at a meadow site within the H.J. Andrews Experimental Forest, Blue River, Oregon (Figure 1). It is situated on a southern facing slope of Frissell Ridge, the eastern border of the forest $\left(44^{\circ} 14^{\prime} 50^{\prime \prime} \mathrm{N}, 122^{\circ} 7^{\prime} 39^{\prime \prime} \mathrm{W}\right)$ at an elevation of about 590 m (Figure 2). The study meadow is defined by an abrupt eastern forest edge, a northern edge where young
trees are invading the meadow, and a western edge where older trees have invaded the meadow. The southern edge of the meadow is defined by Forest Service Road 1506 (Figure 3).

## Methods

## Field Methods

Seven trees were selected for sampling, representing a rough outline of the meadow along the forest edge. These trees were $>65 \mathrm{~cm}$ in diameter, and $>25 \mathrm{~m}$ in height. The first tree was subjectively chosen at a distance of about 80 m from FS Road 1506 to avoid surveying portions of the meadow that could have been adversely affected by the presence of the road, and to ensure that transects could be laid out into open meadow. The second and third trees sampled were spaced out by roughly 40 paces along the forest edge. Because the northern edge of the meadow was very young, and shorter than the eastern and western edges, only one tree was selected, situated roughly in the center of the edge. The fourth tree was situated near the top of the western edge, and the fifth and sixth trees were selected at locations where transects would not be affected by the large trees that are invading the meadow.

For each tree selected to be surveyed, diameter at breast height (DBH) and height of the tree were obtained. From the base of each tree, a 20 m transect was laid out pointing toward the center of the meadow. One $\mathrm{m}^{2}$ vegetation survey plots were placed at $0,1,3,5,7,9,15$, and 19 meters from the base of the tree (Figure 4). Within each $1 \mathrm{~m}^{2}$ plot, all forb species were identified using Plants of the Pacific Northwest Coast, compiled by Jim Pojar and Andy MacKinnon, and a stem count was recorded for each species present.

## Data Analyses

## Species Richness

To calculate species richness, abundance of individual plants as a function of distance from the trees was first determined (Fig. 5). Species lists and counts of individuals were created for each $1 \mathrm{~m}^{2}$ plot, and plots were grouped by distance from the tree (Tables 1a to 1 h ). This resulted in eight tables, each including average species richness at a specified meter for each tree, and standard deviation between all of the trees for that meter. Using these tables, a graph was created to visualize how species richness changed with distance from the forest edge (Figure 6). Species lists were used to generate pairwise similarity to determine how many species were shared by plots at a given distance from the trees. This depicts the change in shared species as distance from the forest edge increases (Figure 7). To analyze the turnover between understory and meadow plots, data matrices were generated with only meters $0,1,15$ and 19 , looking for differences in meters 0 and 1 versus 15 and 19 (Figure 11).

## Dominance

Species dominance was determined by dividing the number of individuals of each species by the total number of individuals found in the plot. These data were pooled by distance from the tree, and depicts how dominance changes with distance from the forest edge (Figures 12a-12h).

## Results

## Species Richness as a Function of Distance

Trees 2,5 , and 7 had very high values for number of individuals in the plots situated under the canopy (Figure 5). These high values can be attributed to abundant dominant species, such as Claytonia sibirica or Smilacina stellata, which were not found beyond seven meters
from the nearest tree (Figures 12a-12h). Data for mean species richness as a function of distance from trees reveals a steady increase in richness with distance from the forest edge, with about $2 \mathrm{spp} . / \mathrm{m}^{2}$ at the base of the tree, and peak richness of 5 to $6 \mathrm{spp} . / \mathrm{m}^{2}$ between 9 and 15 meters from the base of the tree(Table 1, Figure 6).

## Similarity of Species as a Function of Distance

Plots that are situated further into the meadow have higher similarity than plots under trees. Pairs of plots within 5 m of trees tended to share only $10 \%$ of their species, whereas plots more than 5 m from trees tended to share about $20 \%$ of their species. In this survey, variance of species appears to be higher in plots that are situated in the meadow (Table 2, Figure 7). Similarity of Species Richness by Tree

Five of seven transects had complete turnover (zero pairwise similarity) between understory plots 0 and 1 versus meadow plots 15 and 19 (Table 3, Figure 9). Species Dominance

Dominance declined with distance from trees. Plots within 3 m of trees tended to be dominated by one or two species each of which represented more than $30 \%$ of the individuals in the plots, while all other species represented less that $5 \%$ (or occasionally $10 \%$ ) of individuals (Fig. 12). In contrast, from 5 to 9 m from trees, no single species represented more that $25 \%$ of the individuals, and seven to nine species each represented more than 5\% of individuals (Fig. 12). At 15 and 19 m from trees, four or five species were somewhat dominant (ORTHIMBR, ERIGPERE, ERIOLANA) (Fig. 12).

## Discussion

## Species Richness

Species richness increases with distance from the forest edge. Average richness peaks between 9 and 15 meters, and these meadow plots share about $20 \%$ of their species. Average species richness does not vary much between trees, and plots near trees share very few species. The presence of herbaceous meadow species inhibits the success of invading saplings, as it is difficult for them to survive when beneath dense forb cover (Magee \& Antos 1992). With data supporting the notion that species richness of forb communities is decreased below the canopy of trees at the forest edge, it seems apparent that continued tree invasion into the meadow will gradually decrease the fragile forb communities.

## Dominance of Species

Species dominance changes dramatically from the forest understory to the open meadow. Under the canopy, species that are dominant consist of Claytonia sibirica and Smilacina stellata, neither of which are meadow species. Conversely, the meadow plots (see Figures 12 g and 12 h ) do not show dominance of these species, or presence of these species at all in the meadows. A complete turnover of species present can be more clearly seen in Figure 9. Species that are commonly present in montane meadows of the cascades make up most of the dominant species found in the meadow plots, which was expected.

## Conclusions

This study aims to provide quantitative information regarding the forb community composition of a small montane meadow in the Central Oregon Cascades. Results portray a clear transition from forest understory to open meadow, where the abundance of herbaceous meadow species continually increases from forest plots to meadow plots. With the absence of meadow species under the canopy of trees at the forest edge, the likelihood of these species surviving as trees continue to invade is not very high. If meadow species cannot invade the forest understory (e.g. Magee \& Antos 1992), and no disturbances such as fire inhibit the invasion of trees, tree canopies will continue to exclude meadow herbaceous species.

## Figures

Figure 1: Map of H.J. Andrews Experimental Forest, source: H.J. Andrews Experimental Forest website.


Figure 2: Location of Meadow Site in H.J. Andrews Experimental Forest


Figure 3: Map of Meadow Study Site

Study Site at H.J. Andrews Experimental Forest


Figure 4: Diagram of transect set-up


Figure 5: Plot of the total number of individual plants as a function of distance from the trees.


Figure 6: Average species richness of all trees, by distance from tree.


Figure 7: Pairwise similarity in understory plants as a function of distance from tree


Figure 8: Average species richness by tree


Figure 9: Pairwise similarity between trees


Figure 10: Fire History Reconstruction Map, H.J. Andrews, credit Frederick J. Johnson


Figure 11: Pairwise similarity spreadsheets comparing understory plots $(0,1)$ with meadow plots $(15,19)$ for all trees. Highlighted cells were used to calculate averages and standard deviations.

| Tree 1 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{1 5}$ |  |
| :--- | ---: | ---: | ---: | ---: |
| $\mathbf{1}$ | 0.5 |  |  |  |
| $\mathbf{1 5}$ | 0 | 0 |  |  |
| $\mathbf{1 9}$ | 0 | 0 | 0.6 |  |
| ave |  |  |  | 0 |
| stdev |  |  |  | 0 |


| Tree 2 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{1 5}$ |  |
| :--- | ---: | ---: | ---: | ---: |
| $\mathbf{1}$ | 1 |  |  |  |
| $\mathbf{1 5}$ | 0 | 0 |  |  |
| $\mathbf{1 9}$ | 0 | 0 | 0.5 |  |
| ave |  |  |  | 0 |
| stdev |  |  |  | 0 |


| Tree 3 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{1 5}$ |  |
| :--- | ---: | ---: | ---: | ---: |
| $\mathbf{1}$ | 0.2 |  |  |  |
| $\mathbf{1 5}$ | 0 | 0.2 |  |  |
| $\mathbf{1 9}$ | 0 | 0.1 | 0.6 |  |
| ave |  |  |  | 0.08 |
| stdev |  |  |  | 0.11 |


| Tree 4 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{1 5}$ |  |
| ---: | ---: | ---: | ---: | ---: |
| $\mathbf{1}$ | 0.3 |  |  |  |
| $\mathbf{1 5}$ | 0.1 | 0.4 |  |  |
| $\mathbf{1 9}$ | 0.3 | 0.4 | 0.3 |  |
| ave |  |  |  | 0.32 |
| stdev |  |  |  | 0.12 |


| Tree 5 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{1 5}$ |  |
| ---: | ---: | ---: | ---: | ---: |
| $\mathbf{1}$ | 0.3 |  |  |  |
| $\mathbf{1 5}$ | 0 | 0 |  |  |
| $\mathbf{1 9}$ | 0 | 0 | 0.6 |  |
| ave |  |  |  | 0 |
| stdev |  |  |  | 0 |


| Tree 6 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{1 5}$ |  |
| :--- | ---: | ---: | ---: | ---: |
| $\mathbf{1}$ | 0 |  |  |  |
| $\mathbf{1 5}$ | 0 | 0 |  |  |
| $\mathbf{1 9}$ | 0 | 0 | 0.5 |  |
| ave |  |  |  | 0 |
| stdev |  |  |  | 0 |


| Tree 7 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{1 5}$ |  |
| :--- | ---: | ---: | ---: | ---: |
| $\mathbf{1}$ | 0.8 |  |  |  |
| $\mathbf{1 5}$ | 0 | 0 |  |  |
| $\mathbf{1 9}$ | 0 | 0 | 0.4 |  |
| ave |  |  |  | 0 |
| stdev |  |  |  | 0 |

Figures 12a-h: Species dominance of each plot for all trees surveyed.
12a


12b


12c


12d


12e


12f


12 g


12h


## Tables

Tables 1a-h: Pairwise similarity spreadsheets comparing similarity of species found at each tree.
1a

| meter 0 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Tree 2 | 0 |  |  |  |  |  |  |
| Tree 3 | 0 | 0.5 |  |  |  |  |  |
| Tree 4 | 0 | 0 | 0 |  |  |  |  |
| Tree 5 | 0 | 0.33 | 0.25 | 0 |  |  |  |
| Tree 6 | 0 | 0 | 0 | 0 | 0 |  |  |
| Tree 7 | 0 | 0.25 | 0.2 | 0 | 0.4 | 0 |  |
| ave |  |  |  |  |  |  | 0.09 |
| stdev |  |  |  |  |  |  | 0.16 |

1b

| meter 1 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Tree 2 | 0 |  |  |  |  |  |  |
| Tree 3 | 0 | 0.2 |  |  |  |  |  |
| Tree 4 | 0 | 0 | 0 |  |  |  |  |
| Tree 5 | 0 | 0 | 0 | 0 |  |  |  |
| Tree 6 | 0 | 0 | 0 | 0 | 0 |  |  |
| Tree 7 | 0 | 0.33 | 0.14 | 0 | 0.33 | 0 |  |
| ave |  |  |  |  |  |  | 0.05 |
| stdev |  |  |  |  |  |  | 0.12 |

1c

| meter 3 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| Tree 2 | 0 |  |  |  |  |  |  |
| Tree 3 | 0.14 | 0.2 |  |  |  |  |  |
| Tree 4 | 0.3 | 0.1 | 0.1 |  |  |  |  |
| Tree 5 | 0 | 0 | 0 | 0 |  |  |  |
| Tree 6 | 0.43 | 0 | 0 | 0.18 | 0 |  |  |
| Tree 7 | 0.14 | 0.2 | 0 | 0 | 0 | 0.14 |  |
| ave |  |  |  |  |  |  | 0.09 |
| stdev |  |  |  |  |  |  | 0.12 |

1d

| meter 5 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Tree 2 | 0.17 |  |  |  |  |  |  |
| Tree 3 | 0.1 | 0.3 |  |  |  |  |  |
| Tree 4 | 0 | 0 | 0.09 |  |  |  |  |
| Tree 5 | 0 | 0 | 0 | 0 |  |  |  |
| Tree 6 | 0 | 0.11 | 0.08 | 0.13 | 0 |  |  |
| Tree 7 | 0 | 0 | 0 | 0 | 0 | 0 |  |
| ave |  |  |  |  |  |  | 0.05 |
| stdev |  |  |  |  |  |  | 0.08 |

1e

| meter 7 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Tree 2 | 0.75 |  |  |  |  |  |  |
| Tree 3 | 0.6 | 0.5 |  |  |  |  |  |
| Tree 4 | 0 | 0 | 0.13 |  |  |  |  |
| Tree 5 | 0.375 | 0.11 | 0.1 | 0.11 |  |  |  |
| Tree 6 | 0.25 | 0.22 | 0.1 | 0.25 | 0.3 |  |  |
| Tree 7 | 0 | 0 | 0.2 | 0.22 | 0 | 0 |  |
| ave |  |  |  |  |  |  | 0.2 |
| stdev |  |  |  |  |  |  | 0.21 |

1f

| meter 9 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Tree 2 | 0.38 |  |  |  |  |  |  |
| Tree 3 | 0.22 | 0.75 |  |  |  |  |  |
| Tree 4 | 0.22 | 0.27 | 0.17 |  |  |  |  |
| Tree 5 | 0 | 0.1 | 0.1 | 0.1 |  |  |  |
| Tree 6 | 0.11 | 0.08 | 0.08 | 0.3 | 0.25 |  |  |
| Tree 7 | 0.17 | 0.11 | 0.11 | 0 | 0.17 | 0.14 |  |
| ave |  |  |  |  |  |  | 0.18 |
| stdev |  |  |  |  |  |  | 0.16 |

1 g

| meter 15 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Tree 2 | 0.33 |  |  |  |  |  |  |
| Tree 3 | 0.43 | 0.25 |  |  |  |  |  |
| Tree 4 | 0.11 | 0.43 | 0.2 |  |  |  |  |
| Tree 5 | 0.22 | 0.1 | 0.08 | 0.18 |  |  |  |
| Tree 6 | 0.13 | 0.29 | 0.1 | 0.22 | 0.09 |  |  |
| Tree 7 | 0.11 | 0.25 | 0.2 | 0.33 | 0.18 | 0.38 |  |
| ave |  |  |  |  |  |  | 0.22 |
| stdev |  |  |  |  |  |  | 0.11 |

1h

| meter 19 | Tree 1 | Tree 2 | Tree 3 | Tree 4 | Tree 5 | Tree 6 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Tree 2 | 0.33 |  |  |  |  |  |  |
| Tree 3 | 0.25 | 0.25 |  |  |  |  |  |
| Tree 4 | 0.22 | 0.43 | 0.2 |  |  |  |  |
| Tree 5 | 0.5 | 0.1 | 0.08 | 0.18 |  |  |  |
| Tree 6 | 0.09 | 0.29 | 0.1 | 0.22 | 0.09 |  |  |
| Tree 7 | 0.11 | 0.25 | 0.2 | 0.33 | 0.18 | 0.38 |  |
| ave |  |  |  |  |  |  | 0.23 |
| stdev |  |  |  |  |  |  | 0.12 |

Table 2 : Average species richness for each meter between all trees.

| Distance | Ave <br> Richness | STDEV <br> Richness |
| ---: | ---: | :--- |
| $\mathbf{0}$ | 1.86 | 1.35 |
| $\mathbf{1}$ | 2.86 | 2.79 |
| $\mathbf{3}$ | 4 | 2.24 |
| $\mathbf{5}$ | 4 | 2.31 |
| $\mathbf{7}$ | 4.43 | 1.72 |
| $\mathbf{9}$ | 5.43 | 1.72 |
| $\mathbf{1 5}$ | 5.43 | 1.33 |
| $\mathbf{1 9}$ | 5 | 1.29 |

Table 3: Pairwise similarity as a function of distance.

| Distance | Mean Pairwise Sim. | stdev Pairwise Sim. |
| ---: | ---: | ---: |
| $\mathbf{0}$ | 0.09 | 0.16 |
| $\mathbf{1}$ | 0.05 | 0.12 |
| $\mathbf{3}$ | 0.09 | 0.12 |
| $\mathbf{5}$ | 0.05 | 0.08 |
| $\mathbf{7}$ | 0.2 | 0.21 |
| $\mathbf{9}$ | 0.18 | 0.16 |
| $\mathbf{1 5}$ | 0.22 | 0.22 |
| $\mathbf{1 9}$ | 0.23 | 0.23 |

Table 4: Pairwise similarity as a function of tree.

| Tree | Mean Pairwise Sim. | stdev |
| ---: | ---: | ---: |
| $\mathbf{1}$ | 0 | 0 |
| $\mathbf{2}$ | 0 | 0 |
| $\mathbf{3}$ | 0.083 | 0.11 |
| $\mathbf{4}$ | 0.32 | 0.12 |
| $\mathbf{5}$ | 0 | 0 |
| $\mathbf{6}$ | 0 | 0 |
| $\mathbf{7}$ | 0 | 0 |

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