“Forb Diversity in 47-year-old and 300-year-old aged stands at the HJ Andrews LTER Forest”

Abstract

Point line intercept and meter squared quadrant data were collected from two adjacent stands; one was clear-cut logged 47 years ago (referred to as a plantation) and the other is old growth forest that has been undisturbed for at least 300 years. The goal of this study was to understand forb relationships through community analyses in order to better be able to manage ecosystems in healthy manner to meet all its users' needs. Over story cover was significantly different between the two sites. One set of data showed a significant difference in percent cover between the two ecosystems, while the other set demonstrated significant difference in species richness between the ecosystems. No significant difference was found between the different aged forest stands for species evenness and Shannon and Simpson diversity indices. The Sørensen Similarity Index indicates that the difference between transects in the plantation are as great as the differences between the two ecosystems. Sword Fern, Sierra Sanicle, and Whipplevine were the dominant species at both sites; Sierra Sanicle was much more abundant in the old growth plot while the other two plants were present in greater quantities in the plantation plot. Twinflower and moss, although not forbs, were quite abundant in both ecosystems and are major competitors with the forbs for nutrients and space. Overall, both sites seemed similar in most regards; further in-depth study of these ecosystems is advised to better understand the abiotic and biotic interactions occurring at these sites.

Introduction

It has been well documented that forests, like an individual organism, go through stages of growth and development, referred to as succession (Hall, 1991.) Unlike an individual organism, though, their development can be “reversed” when the ecosystem experiences a primary or secondary disturbance event. Recently scientists have been studying various types of disturbance events and how they affect the successional stages of forest growth.

In the Pacific Northwest (PNW), where logging forests has been a mainstay of local economies since manifest destiny sent European colonists west to claim ownership of and “civilize” the “wild lands,” managing forests is becoming an important skill (Halpern, 1995.) To successfully do so, management entities like the Forest Service and the Bureau of Land Management have to balance public desire, politics, and scientific knowledge to reach management strategies that meet the needs of all users of the forest ecosystem. This paper is focused on increasing our scientific understanding of the complexity of abiotic and biotic interactions occurring in a PNW ecosystem, specifically comparing the understory diversity of a forest that was clear-cut 47 years ago (henceforth referred to as “plantation”) to an approximately 300 year-old forest.

In the recent past, scientists have equated species diversity with ecosystem health. This way of thinking about an ecosystem has come under fire as new findings show that health is might be tied more to stability than pure number of different species present and/or their distribution patterns (McCann, 2000); no definite conclusion has met widespread acceptance yet (Tilman, 1996.)

Being able to describe the general characteristics of a particular growth stage of a forest can provide forest managers with a "starting point" and an "end point." These two chunks of information provide forest managers with clues about what management techniques to use and which goals to set as they strive to nurse a disturbed ecosystem, in this case a clear-cut, through the recovery process and get it back on track to growing into a mature ecosystem that is stabile and diverse. As stability needs to be measured over a longer period of time, this study sought to examine the intricacies of understory species diversity between the two different aged forest stands, although if implications concerning stability arise then they could be suggestions for future scientific study at the HJ Andrews LTER (Long Term Ecological Research) Forest.

The hypothesis for this study was that there would be a greater species richness of forbs in the plantation forest than the old growth forest, but that there would be greater forb evenness in the old growth forest than in the plantation forest at the HJ Andrews LTER Forest. The rationale was that the increased presence of light in the plantation would allow for a greater variety of forbs while the age of the old growth forest would permit plants to take advantage of all available niches in the established forest.

Methods

Two adjacent plots, a plantation (forest that was clear-cut 47 years ago) and an approximately 300 year-old forest, in the HJ Andrews LTER Forest, were sampled in two manners: point line intercept and one-meter squared quadrants. Both sets of data were collected along five transects, 20 meters each, that were spaced five meters apart from each other and running north to south. When comparing point line intercept data against quadrant data, each data set will be treated as corroboration of the other, i.e. if we get the same results from different data gathering methods, results are more credible; If conflicting information is provided from the different data collection procedures it will be noted in the "Results" section and confidence in the results will not be strong.

To collect data for the point line intercept data collection method, every 20 cm a stick was touched down to the ground and the first two plants that the stick touched (preferential order being from the ground up) were recorded. To collect one-meter squared quadrant data, a point every four meters along the transect was used as the center of the quadrant and percent cover of all plants (including overstory plants) was calculated and recorded.

Densitometer readings were made on a separate day in the same area as each of the previously sampled ecosystems, but not directly over the transects from where the plant data was collected, therefore this information will only be used a general sense to make a general comparison of light availability in each of the ecosystems.

Results

Light

Densitometer readings indicated that the overstory cover in the old growth forest, 93.3%, was significantly more than in the plantation, 82.3% ($p = 0.03$.)

Percent cover

Percent cover of forbs was greater in the plantation than the old growth forest (Table A); according to the quadrant data it was significantly different ($p = 0.05$) while the point line intercept data indicated that the difference was insignificant ($p = 0.25$.)

Species richness

As with percent cover, conflicting results were give from the two data collection methods (Table A): the plantation's species richness was significantly higher ($p = 0.04$) than that of the old growth forest's if one looks at the point line intercept data, but the quadrant data shows no correlation ($p = 0.75$.)

Table A.

	Point Line Intercept Plant Abundance			*Quadrant Percent Cover*		
	Old Growth	**Plantation**	**P-value**	**Old Growth**	**Plantation**	**P-value**
Percent Cover (%)	16.8	25	0.25	9.6	22.8	0.05
Species Richness	3.8	6.2	0.04	6.6	7.0	0.75

Species evenness

Analysis of species evenness did not indicate a significant difference between the ecosystems (quadrant data $p = 0.72$; point line intercept data $p = 0.37$.)

Diversity index

Neither index, Shannon or Simpson, or sampling method demonstrated a significant difference in species diversity (quadrant data $p = 0.72$ and $p = 0.57$, respectively; point line intercept data $p = 0.15$ and $p = 0.36$, respectively.)

Similarity Data

When considering the Sørensen Similarity Index, both sampling techniques were congruent in their conclusions (Table B.) Plantation transects were as dissimilar to each other, approximately 25%, as they were when compared with the old growth forest transects.

Table B.		
Transects Being Compared	**Quadrant Data**	**Line Intercept Data**
Average of Sørensen Similarity Index Comparing Transects from Old Growth to Transects from Plantation	0.280904	0.20252
Average of Sørensen Similarity Index Comparing Transects within Old Growth to Each Other	0.5541	0.5022
Average of Sørensen Similarity Index Comparing Transects within Plantation to Each Other	0.287	0.3068

Forb influence relative to other understory dominants

Forbs were 7.9% more dominant in the plantation ecosystem than the old growth forest ecosystem. When one factors in two other major dominant ecosystem plants that are not classified as forbs, yet live in the same understory layer with them and thus compete against the forbs for light and other resources, the amount of the ecosystem that the understory layer (classifying purely by the plant's height) affects becomes more apparent.

Table C.				
Point Line Intercept				
Ecosystem Type	*Forb Dominance (%)*	*Forb + Twinflower Dominance (%)*	*Forb + Moss Dominance (%)*	*Forb + Moss + Twinflower Dominance (%)*
Plantation	15.7	27.4	43.7	55.4
Old Growth	7.8	11.8	44.0	48.0

Table D.					
Percent Cover					
Ecosystem Type	*Sum of Average Percent Cover of Forbs*	*Sum of Average Percent Cover of Non-Forbs*	*Sum of Average Percent Cover of Forbs + Twinflower*	*Sum of Average Percent Cover of Forbs + Moss*	*Sum of Average Percent Cover of Forbs + Moss + Twinflower*
Plantation	22.8	110.6	35.3	73.0	85.44
Old Growth	3.9	160.2	8.6	94.5	99.3

Focusing on dominant forb plants

All forb plants present in both data collection methods were graphed (Figures 1 and 2.) Dominant forbs were selected for further analysis. Three dominant forbs common to both ecosystems were identified by the criteria that they must have an average abundance and average percent cover difference of greater than five between the two ecosystems. The average abundance and average percent cover of each species, Sword Fern, Sierra Sanicle, and Whipplevine, in each transect of each ecosystem were compared (Table E.) Although there is variation in significance amongst the plants and between sampling methods, general trends can be seen, i.e. there is more Sword Fern and Whipplevine in the Plantation and more Sierra Sanicle in the old growth forest.

Table E.						
	Point Line Intercept Plant Abundance			*Quadrant Percent Cover*		
Plant	**Old Growth**	**Plantation**	**P-value**	**Old Growth**	**Plantation**	**P-value**
Sword Fern	2.4	44.8	0.08	0.4	37.0	0.13
Sierra Sanicle	64.3	7.2	0.01	60.4	24.0	0.94
Whipplevine	1.2	12.8	0.10	0.8	6.7	0.13

Figure 1. **COMPARISON OF FORB AVERAGE PERCENT COVER DOMINANCE BETWEEN TWO DIFFERENT AGED FOREST STANDS**

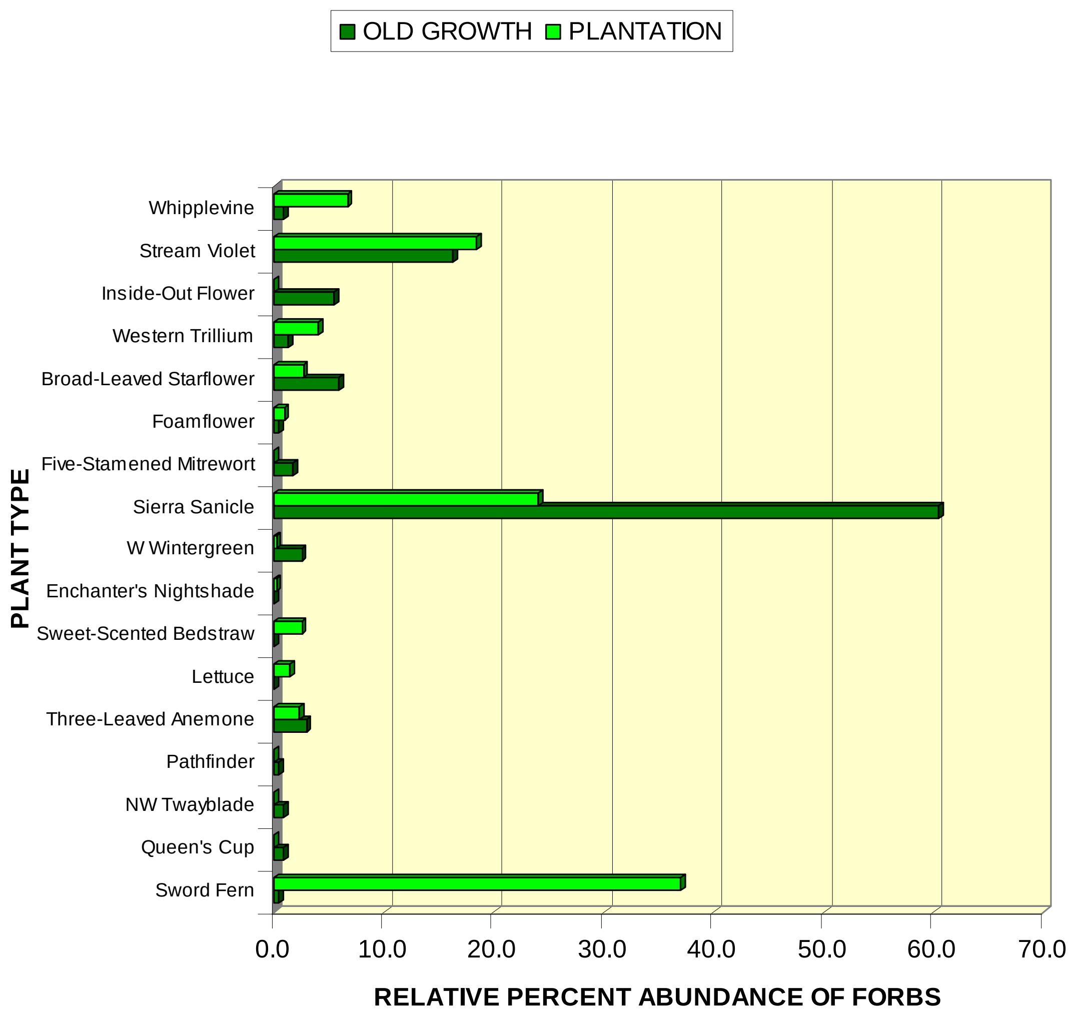
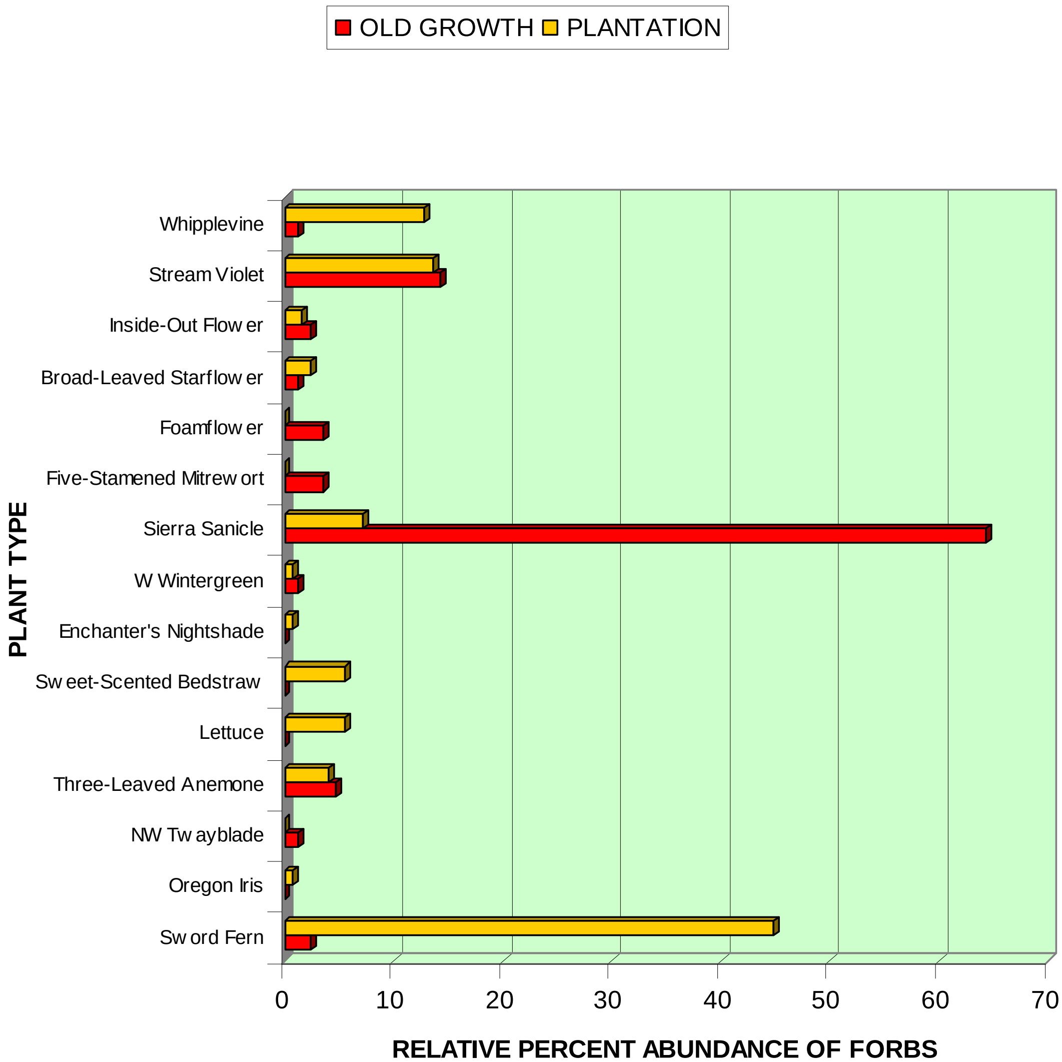


Figure 2. **COMPARISON OF AVERAGE FORB POINT LINE INTERCEPT ABUNDANCE BETWEEN TWO DIFFERENT AGED FOREST STANDS**



Discussion

As there is less overstory coverage in the plantation, there is more light available to understory plants. This could be one reason that we observed greater forb dominance and plant cover in the plantation than the old growth forest (Tables C and D.) Additionally, according to the point line intercept data, a total of 41 more plants were present in the plantation than in the old growth forest. As the forests are located adjacent to each other, differences in other abiotic factors besides amount of light seem negligible, although proximity of the two sites to each other could lead to “edge effects” and could be a reason that few differences were seen between the sites and why one data collection method sometimes lead to significantly lower p-values than the another data collection method.

Besides conflicting information about a significant difference between percent cover and species richness when comparing the two sites, species evenness and the Shannon and Simpson diversity indices did not indicate a significant difference between the two ecosystems which makes one consider that the integrity of the two ecosystems is reasonably equivalent. When comparing old growth forests to other aged and managed stands in northern hardwood forests, scientists observed trends that this study also shows, namely that species percent cover and richness was lower in old growth forests (Scheller, 2002.) It could be argued that each of the different aged ecosystems of this study is on the verge of being different enough from the other that it will be shown to be so statistically and so that is why one way of analyzing a site’s diversity shows significance and another’s does not, especially when it is not always the same data collection technique that leads to significant values. Or maybe the reverse is the case, and the plantation was initially unhealthy, but has quickly caught up to the steady-state that the neighboring old growth forest is at, even before the canopy has closed up to the extent that is has in the old growth forest, as other scientists have observed occurring in other logged PNW forests (Halpern, 1995.)

Although not exactly a measure of diversity, the Similarity Index can be another way of viewing that parameter in a more holistic manner. The Sørensen Similarity Index shows that the plantation has a greater heterogeneity within itself as compared to old growth (Table B.) In an Appalachian oak forest, scientists hypothesize that observed spatial heterogeneity is correlated to the study’s observed increase in species richness of a clear cut as compared to a mature forest (Small, 2002.) This analysis supports the intent of the initial hypothesis: that there will be more richness but less evenness in the plantation than the old growth forest. As already stated, though, direct calculations of richness and evenness show mediocre support for this hypothesis.

Considering the amount of dominance and percent cover of moss and twinflower in both ecosystems (Tables C and D), these two plant types represent major competition for the other forbs; one could postulate that this is because summer is the hardest season in the PNW (water is scarce and temperatures are at their highest) and yet this is the season that forbs have to complete their life cycles. Moss and twinflower, both being evergreen, just have to “weather” the summer and then have the rest of the year to grow and further establish themselves with other components of the ecosystem. When considering competition relationships, viewing the forest through a forb plants versus woody plants “lens” is useful for seasonal observation and interpretation of the forest ecosystem on an annual cycle. The exclusion of non-forb plants from a forb analysis does have its drawbacks though, i.e. competition based on strata level is not considered and thus that aspect of plant interactions is lost.

There is definitely a difference in the amount of the dominant forb species (Table E) in each ecosystem. This could be explained through preferences for different light intensities provided by the different forest canopies. Other studies have shown Sword Fern to be a successful colonizer of Douglas fir logged sites (Bailey, 1999.) Whipplevine is known to preferentially colonize areas that receive more light (Pojar, 2004.) Sierra Sanicle seems to be found equally in both types of ecosystems (Pojar, 2004), so maybe other abiotic forces or biotic competition are at play and that allow the forb to be much more dominant in the old growth forest than in the plantation forest. There could be other abiotic factors affecting the growth of all the plants, but our study did not test any of these. In future studies of these ecosystems, data about nutrient availability, moisture retention, etc. might elucidate why percent cover and abundance of the three dominant species are different between these ecosystems (Halpern, 1995.)

The greatest source of error in this study was inconsistency between teams of data collectors, which could easily be remedied by better communication on-site and clarification of data collection protocol before going to the field to collect data. Of course data from more plots over a longer time period would yield more data and increased reliability of analysis results.

Based on data and results from this study, one could pursue several lines of inquiry. One would be to test other abiotic parameters to decipher if light is the only key abiotic variable affecting these ecosystems. Secondly, a lower number of plants in the old growth forest is puzzling, as it has been left undisturbed for a longer period of time, one would think that the decomposer communities and mycorrhizal associations (Jones, 2003) would be well established and make it easier for plants to grow by increasing access to nutrients. Therefore, one could investigate why this does not seem to be the case when examining these two ecosystems. Maybe looking at below-ground competition (Lindh, 2003; Antos, 1984) would shed light on this situation. Finally, analyzing competition between understory herbs, epiphytes and woody plants could elucidate whether being woody or evergreen gives a plant a survival advantage in the plantation and/or old growth forests of the HJ Andrews LTER Forest.

In conclusion the initial hypothesis is not strongly supported, although some of the richness analysis and the similarity index provided minimal and indirect support. Further analysis, like a bigger sample size and sampling of more different aged stands would be useful in teasing the hypothesis into a definite acceptance or rejection. Further study along these lines might also show stronger support in the other direction, i.e. that species diversity might be the same in different aged stands of neighboring forests and that it is just the type of species that will vary from one particular forest age-stand to the next. The better these associations can be clarified, i.e. how long it takes a stand to reach the stability and diversity it had prior to being cut, the more forest managers can mimic ecosystem processes in ways that will maintain ecosystem health and give the highest yield possible of wood for human consumption (Kimball, 1995; Halpern, 1995.)

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