The effect of forest age and disturbances on ant species

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ABSTRACT

Ants can be and important bio-indicator of forest health. We examined ant diversity in four experimentally burned forests and one accelerated succession forest plot at the University of Michigan Biological Station in Pellston, Michigan. The ages of these plots varied between 32 and 101 years. Petri dishes baited for an hour with sugar and meat were placed in each plot on three different days and diversity was measured based on the amount of morphotypes present in each dish. Morphotype diversity was calculated using species richness and Shannon diversity index. 15 morphotypes were found among plots. Generally, ant diversity decreased with forest age with the exception of the 1936 plot, which was highly diverse. In addition, no diet preference among plots existed between plates baited with meat or sugar. Ant diversity may be an important measurement of forest ecosystem health in transitional habitats.

INTRODUCTION

Successional changes in aging forests are often considered to occur in stages through invasions by various groups of species (Finegan 1984). As a forest ages, its complexity, or heterogeneity of the habitat (Lassau and Hochuli 2004), may increase. Exposure to ecosystem disturbances, including invasive species, forest fires, diseases, and other human-induced changes, may alter the complexity of sensitive forests as the natural progression of succession is distorted (Abrams and Scott 1989).

Ants (Family Formicidae) respond to a range of disturbances and have been used as bio-indicators of ecosystem health (Lassau and Hochuli 2004, Dekoninck *et al.* 2008). Ant species composition can be affected by alterations in shade, vegetation structure, and plant species richness (Lassau and Hochuli 2004). These arthropods are an important component of many biological systems including the decomposition and nutrient cycling in forests (Babayan *et al.* 2004).

Ant species richness has been found to be higher in areas of young growth and low habitat complexity (Fisher 1987, Lassau and Hochuli 2004), which is contrary to other studies suggesting that species richness (and arthropod diversity) is positively correlated with the complexity of a habitat (Babayan *et al.* 2004).

Our study aims to determine the relationship between ant species diversity and forest complexity as a function of forest age. Experimental burn plots on the property of the University of Michigan Biological Station (UMBS) in Pellston, Michigan provide an excellent opportunity to study this relationship due to the long- term burn chronosequence of forest plots created by prescribed forest burns. This study focuses on the diversity of ant species in three of the hectare size burn plot sites within the chronosequence (1936, 1954, and 1980) and one adjacent plot of land naturally burned in 1911.

In addition to comparing species diversity across aging forest plots, an experimental accelerated succession plot was used to compare species richness and diversity in a mid-successional forest—The Forest Accelerated Succession Experiment (FASET). Beginning in 2008 artificially, this experiment is intending to accelerate natural progression by girdling the early successional species of Big Tooth Aspen, (*Populus grandidentata*) Trembling Aspen (*Populus tremuloides*), and American White Birch (*Betula papyrifera)*. The forest canopy has opened up and woody debris has accumulated on the forest floor along with more ground- level vegetation in certain areas. Although much data have been collected on these premises, little is known about the effect of forest disturbance on ant species within this particular forest plot. Our study aims to quantify the effect of this accelerated succession through measurements of species richness and diversity and compare them to various burn plots.

Using ant morphotypes distinguished by size and color as a determinate of distinctive species, we hypothesize that ant diversity decreases with forest age due to their nature as pioneer species.

In addition, a general diet preference of carnivorous or omnivorous can be compared between plots presented with both sugar and meat bait options. It is predicted that species found in the younger and FASET plots will be predominantly carnivorous and prefer meat due the carnivorous species of ants that generally prefer to reside in woody debris.

MATERIALS AND METHODS

Study Area: The study took place on several pre-gridded sites located near the University of Michigan Biological Station (UMBS) in Pellston, Michigan—the FASET plot (45° 33' 35.0'' N, 84° 42' 49.6'' W), three controlled burn sites (1936, 1954, and 1980) within the burn plots (45° 33' 30.35'' N, 84° 42' 05.47'' W), and one natural burn site (from a fire in 1911) directly adjacent to the plots. The FASET plot is a mid-successional mixed forest with a large volume of woody debris. The 1911, 1936 and 1954 plots are mixed deciduous forests with varying levels of scattered woody debris whereas the 1980 plot is largely dominated with Aspen species (*Populus grandidentata* and *Populus tremuloides*).

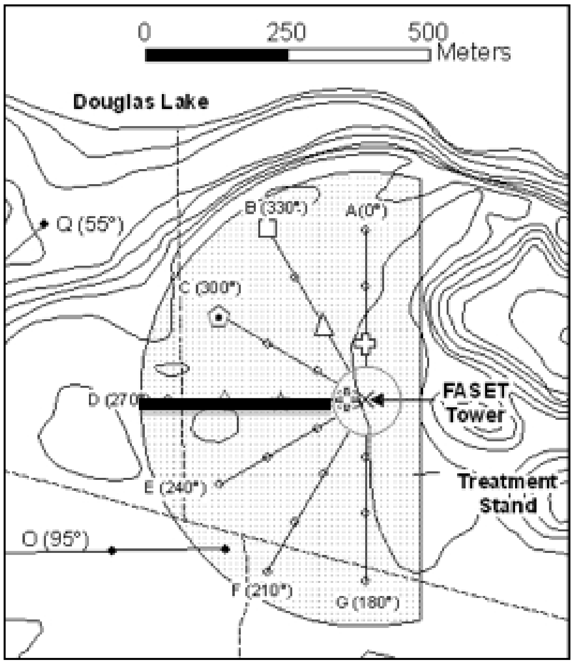

Figure 1. Map of the FASET tower and transects. The thick line indicates the transect used (UMBS Forest Accelerated Succession ExperimenT).

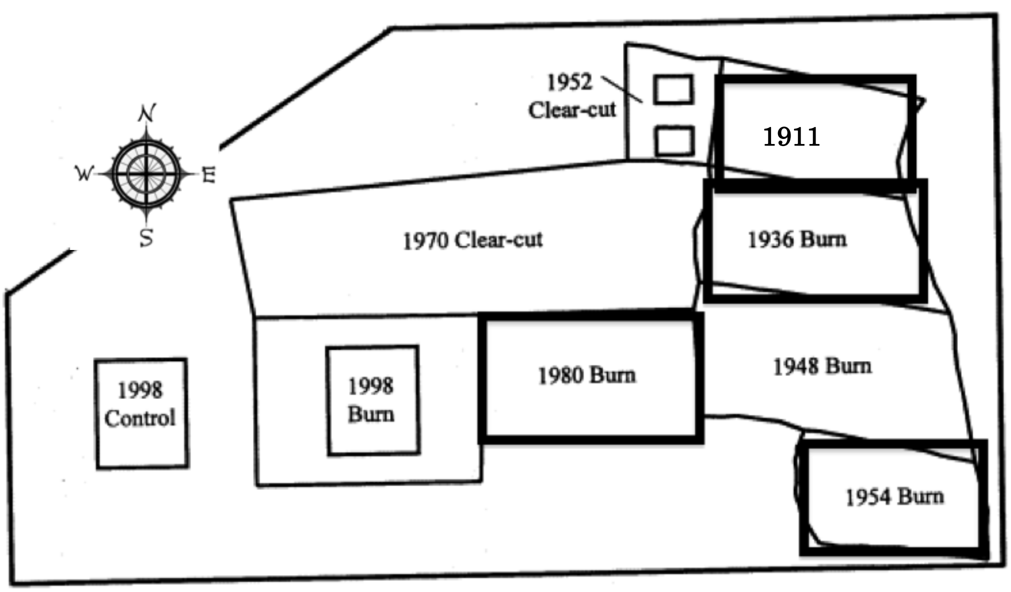

Figure 2. Map of the UMBS clear-cut and burn chronosequence in northern lower Michigan. The thick lines indicate plots used including the experimental burn plots of 1936, 1954, and 1980 as well as the adjacent 1911 natural burn area (UMBS Burn Plots).

A single transect in the FASET plot was set starting 30m from the tower and extending 200m out with 10 flags marking sample areas 10m apart. Single transects were also set diagonally from the northeast to the southwest corner across the three experimental burn plots of 1936, 1954, and 1980 with a 5m boarder to buffer from edge effects. Flags marking sampling areas were set 10m apart in the 1954 and 1980 plots and 20m in the 1936 plot due to size differences. The fifth transect was set outside of the eastern edge of the burn plot area in a natural burn area from 1911. This transect ran directly north for 200m with flags 10m apart.

Experimental Set-up and Data Collection— Each transect was baited with 20 open petri dishes—10 dishes were baited with 9g of raw ground beef while another 10 were baited with 0.5tsp sugar and one red grape. At each transect flag, one meat and one sugar dish were placed within 1m of the flag. Each site was baited once a day on 7/28/2012, 7/30/2012, and 8/2/2012 in the mid-afternoon (3:00-5:00pm). Dishes were left out for two hours and recollected. Upon recollection, dishes were sealed off with lids to contain all ants present in the dishes. Petri dishes were examined under a dissecting microscope and morphotypes were grouped based on size, color, texture, and abdomen shape (Table 1).

Data Analysis— Species richness was calculated by counting the number of morphotypes that occurred in each plot. The Shannon's diversity index (Patil and Taillie 1982) was used to compare morphotype diversity across plots using an ANOVA analysis.

RESULTS

Characterization of ant morphotypes—Ants were grouped based on size, color, texture, and abdomen shape. Fifteen morphotypes were recognized (Table 1).

Table 1. Distinct morphotypes based on size, color, texture, and abdomen shape.

Morph	Size (mm)	Color	Texture	Abdomen	Other
I.	2 to 4	brown/grey	smooth	striped	
II.	4 to 5	amber	hairy	solid	
III.	5 to 5.5	red/dark orange	smooth	rounded & black	big head
IV.	10	black	hairy	striped	
V.	4 to 5.5	dark brown	smooth	striped	
VI.	2	gold/peach	smooth/sparse hairs	solid	
VII.	4.5 to 5	dark brown	smooth	rounded & black	
VIII.	4.5 to 6.5	brown/grey	smooth	striped	
IX.	11	black	hairy	striped	big head
X.	2	mid brown	smooth	segmented	
XI.	1.5 to 2.5	amber	smooth	striped	
XII.	4	black	sparse hairs	teardrop/striped	
XIII.	8	black	hairy	segmented	heart shaped head

Mean species richness and diversity per plot— Mean species richness and mean Shannon diversity per plot calculated over the three trials (Table 2) and the means were graphed (Figure 1, Figure 2). Plots 1911, 1936, 1954, and 1980 are represented in chronological order. The FASET plot was included at the end of the chronology for comparison due to its lack of precise forest age.

Excluding FASET, there was a significant difference in diversity between plots of varying age based on species richness (ANOVA, p= 0.002) and using the Shannon Diversity index (p= 0.003).

A Tukey post hoc analysis using species richness revealed a significant difference between the 1911 and 1936 plots (p= 0.04), the 1936 and 1954 plots (p= 0.002), and the 1936 and 1980 plots (p=0.037).

A Tukey post hoc analysis using Shannon diversity revealed a significant difference between the 1911 and 1936 plots (p= 0.009), the 1936 and 1954 plots (p= 0.027), the 1911 and the 1980 plots (p= 0.007), and the 1954 and 1980 plots (p=0.020).

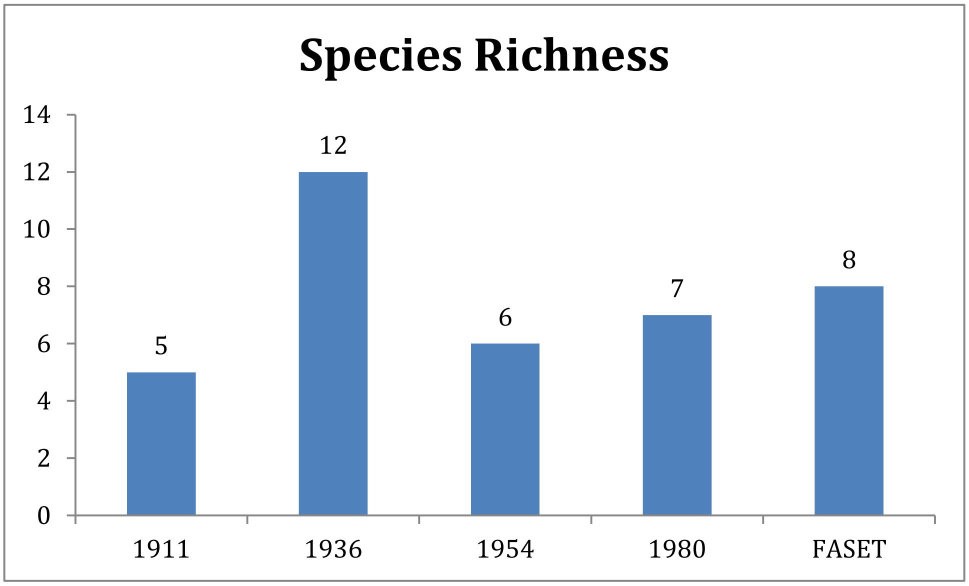

Figure 1. Average species richness by plot in chronological order. FASET is represented at the end for comparison.

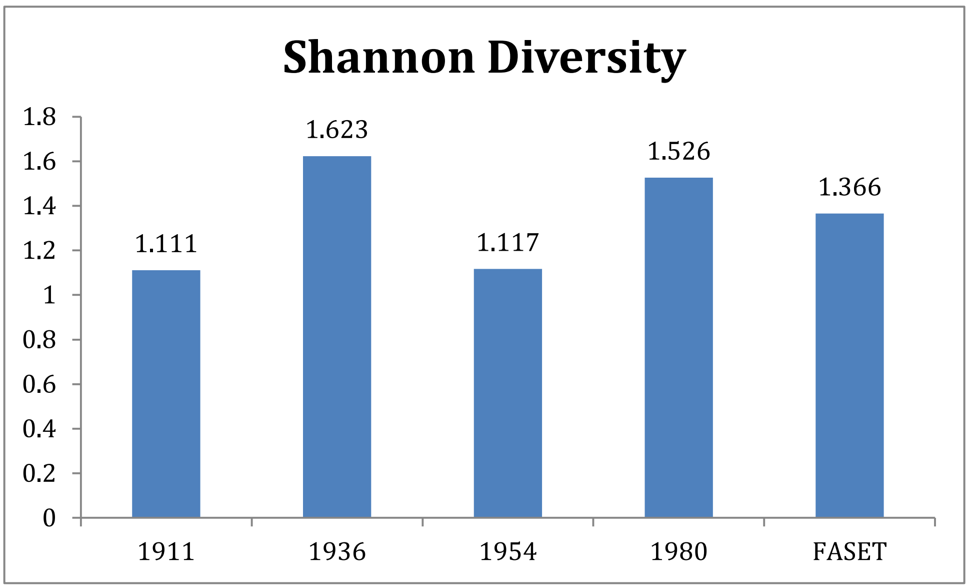

Figure 2. Average Shannon diversity by plot in chronological order. FASET is represented at the end for comparison.

Overall, the 1936 plot showed the greatest diversity, the 1980 plot was relatively diverse, and the 1911 and 1954 plots were of low relative diversity.

Measuring diet preference— Average frequencies of each morphotype present were calculated across plots to measure diet preference trends between sugar and meat. With the exception of morphotype I preferring sugar, there were no diet preference trend seen.

Table 3. Average frequency of morphotypes appearing on sugar and meat across all plots.

	Average Frequency	
Morph	**Sugar**	**Meat**
I.	0.69	0.16
II.	0.53	0.69
III.	0.00	0.01
IV.	0.03	0.01
V.	0.12	0.03
VI.	0.04	0.01
VII.	0.00	0.01
VIII.	0.13	0.04
IX.	0.01	0.01
X.	0.01	0.04
XI.	0.01	0.02
XII.	0.06	0.03
XIII.	0.01	0.01

DISCUSSION

Thirteen different morphotypes were found in total throughout the 1911 and burn plots and FASET. Similarly, a study of these burn plots conducted by Fisher (1987) found 15 species. Although there was a significant difference in diversity between plots based on species richness ($p = 0.002$) and using the Shannon Diversity index ($p = 0.003$), there was no clear trend of diversity with forest age. However, excluding the unusually high diversity of 1936 plot, there is a slight trend of decreasing diversity with forest age, especially using species richness. Ant diversity has been shown to decrease with forest age in other studies as well (Fisher 1987, Farji-Brener 2001). Contrarily, a study on general arthropod diversity confirmed our lack of trend between diversity and forest succession (Babayan 2004).

The unclear trend in diversity with forest age could have been due to several unaccounted factors. Our results could have been dependant on where the petri dishes were placed within the plots. When present in old growth forests, leafcutter ants concentrate their foraging efforts near woody debris and treefall gaps where pioneer plant species grow (Farji-Brener 2001, Penazola 2003). Therefore, petri dishes placed around woody debris and treefall gaps may have created an overrepresentation of certain types of ants such as leafcutters. In addition, our third trial was taken after an overnight storm when temperatures were lower. This could have affected our data because the foraging behavior of many any species are dependent on temperature (Porter 1987).

Dish placement could have also affected our results for diet preference. Plates placed next to woody debris could have attracted a disproportionate amount of carnivorous ants. Past studies have shown that younger forests with more bracken fern (*Pteridium aquilinum)* showed a high preference for sugar due to the pattern of ant activity increasing with availability of fern sugar secretions (Temple 1983).

Even so, the high diversity of ants in the younger forest (1980 plot) suggests their nature as pioneer species. And because the FASET plot had a relatively high diversity in comparison, we suggest that although succession has been sped up, it may still have characteristics of a younger to mid-successional forest. This may be because although the FASET plot was girdled four years ago, many of the trees are still in the process of dying and therefore the site is just beginning to transition into an open, mixed forest and more time is needed in order to complete the habitat differentiation and succession.

Overall, our hypothesis that ant diversity decreases with forest age was supported with the exception of the high diversity found in the 1936 plot. And in comparison, FASET appears to be in a transitional, mid-successional state. In addition, no trend in diet preference was found between plots.

Understanding the trends between forest age and diversity are important in maintaining a rich, healthy forest ecosystem, and the diversity of ants is particularly important due to their ability to indicate environmental health.

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