Abundance and Diversity of Mushrooms in Differently-Aged Forests of Northern Michigan

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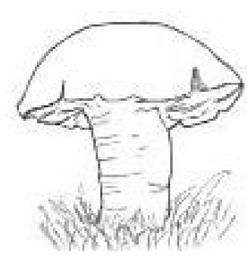
Abstract

The purpose of this study is to examine the relationship between forest age and the abundance and diversity of fungi within. To study this, we looked at four neighboring but distinct segments of forest which underwent controlled burns in 1936, 1954, 1980 and 1998, respectively. Within each plot we ran five transects approximately 75m long, and recorded the species and quantity of mushrooms within two meters of the transect on either side.
We noted the greatest abundance of mushrooms in the 1954 plot, with 547 specimens, and the least mushrooms in the most recently burned 1998 plot – only 11 specimens. The number of species within the four plots ranged from eight to 22, with the greatest number in the 1936 plot. For each transect we calculated the Simpson Index and the Shannon Diversity Index. The Simpson Index showed the 1954 plot as the most diverse, while the Shannon Diversity Index showed the 1936 plot as the most diverse. However, a Tukey Test for both the Simpson Index and the Shannon Diversity Index comparing the four plots showed no statistically significant relationships. Observationally, though, there appears to be a trend in which the largest and most varied mushroom populations occurred in the 1954 plot – the second oldest plot. From this we propose that longer, more in-depth studies of forests undergoing controlled burns might show, to a statistically significant degree, the greatest fungi abundance and diversity in intermediately aged plots, in accordance with the Intermediate Disturbance Hypothesis.



Introduction

Fungi make up one of the six kingdoms of the Linnaean Taxonomy System. Unlike plants, fungi are heterotrophic, needing to consume other organisms to obtain carbon for growth. Fungi often obtain this carbon by decomposing plant matter, and are crucial decomposers in many ecosystems. Mushrooms are the fleshy, spore-bearing fruiting bodies of fungi, which typically appear above ground after rain (Ainsworth, 1950).

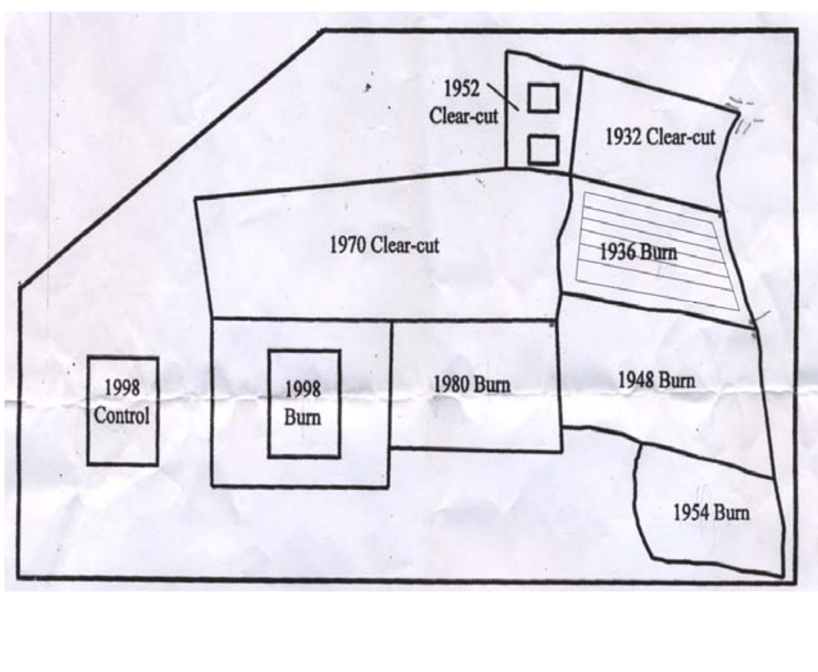
In this study, we examine the relationship between forest age and fungus diversity, as measured by the presence of super-surface mushrooms. We would expect that an older, more established forest will have a greater diversity of fungal species because the fungus populations have had longer to establish and more robust and mature surrounding vegetation from which to find shade, food and other resources.

Methods

Our study site is at the University of Michigan Biological Station in Pellston, MI, USA, where researchers have conducted controlled burns of approximately 2-acre areas in the forest, including sites in 1936, 1954, 1980 and 1998. These burn sites have recovered to varying degrees, and now comprise four distinctly aged forests. In this study, we examine the variation in fungal populations between the four sites.

At each site we ran a transect along the length of the plot, from the NE to NW, discounting 20m on each end to avoid edge effect (Finney, 1948). We used meter sticks to define an area of 2m on either side, and walked along the length of the transects noting the type and quantity of mushrooms at each. For the first sample we ran the transect exactly 20m in from the edge, and following transects were run at 5m intervals (25m, 30m, 35m and 40m westward), leaving one meter of unobserved space between each sample to avoid double-counting (for an example of the transect layouts, see the 1936 plot of Diagram 1). The resulting plot sizes were 4m in width, and approximately 75m in length, depending on the dimensions of the specific burn plot. Twice weekly for two weeks, Sundays and Wednesdays, we visited the burn plots and made observations of the quantity and species of the mushrooms at each, resulting in a total of five data sets (two transects were completed at each site the first day, and one each of the following days).

Diagram 1: Fungi Measurement Example of the Clearcut and Burn Chronosequence, Section 32, Township 37 North, Range 3 West, University of Michigan Biological Station, Cheboygan Co., Northern Lower Michigan



After completing the above observations, we computed the Simpson Index and the Shannon Diversity Index for each of the five transects at all four sites. We grouped the transects by plot year, and ran a Tukey Test to determine whether there were any significant differences between Shannon and Simpson diversity indexes in the differently-aged forest plots. Finally, we plotted the overall mushroom abundances and the overall mushroom diversities against their corresponding year to show visually any trends in forest composition over time.

H0: Plot 1 = Plot 2 = Plot 3 = Plot 4

Ha: Plot 1 ≠ Plot 2 ≠ Plot 3 ≠ Plot 4

Results

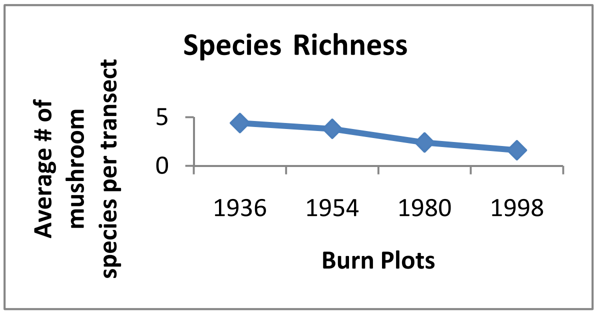
The number of mushrooms found per transect varied widely (Table 1). The gross quantity of mushrooms was highest in the 1954 plot, with 547 observed mushrooms in 19 species, followed by 141 mushrooms in 22 species in the 1936 plot, 36 mushrooms in 12 species in the 1980 plot and 11 mushrooms in eight species in the 1998 plot.

Table 1: Mushroom Richness and Abundance by Plot

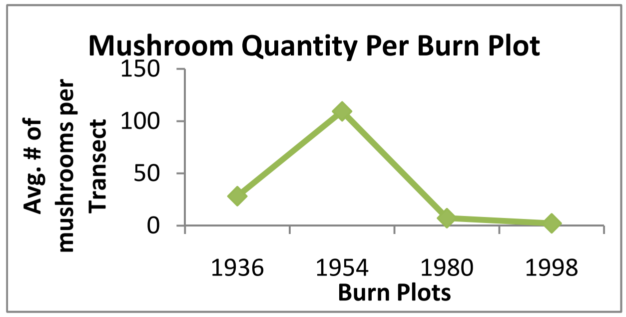
	1936	1954	1980	1998
Richness	22	19	12	8
Avg. Richness per Transect	4.4	3.8	2.4	1.6
Total Mushrooms	141	547	36	11
Avg. Mushrooms per Transect	28.2	109.4	7.2	2.2

In general, species richness seemed to increase as the age of the forest increased (Graph 1). In addition, mushroom quantity per burn plot peaked in 1954, but otherwise also increased with the age of the forest (Graph 2).

Graph 1: Species Richness by Burn Plot



Graph 2: Mushroom Quantity by Burn Plot



We next calculated the Shannon Diversity Indexes and the Simpson Diversity for each transect, and found the average for each burn plot (Table 2). The Shannon Index indicates that the most diverse plot was the 1936 plot, while the Simpson Diversity points to the 1954 plot as the most diverse (Begon, Townsend and Harper, 2006).

Table 2: Diversity Indexes by Plot

Transect	AverageShannon Diversity Index	Average Simpson Diversity
1936	0.869846	0.44620864
1954	0.523152	0.36247
1980	0.63657	0.61869
1998	0.46648	0.7222

Using the non-averaged Shannon and Simpson diversity indexes for each transect, and grouping them by plot, we ran a Tukey Test to determine whether there were statistically significant differences in the Simpson Index or the Shannon diversity Index between the differently-aged forests (Appendix, Table 3-4). The lowest p-values were between the 1936 and 1998 plots for the Shannon Diversity Tukey Test, and between the 1980 and 1998 plots for the Simpson Diversity Tukey Test, but no values were below the threshold necessary for statistical significance.

Discussion

During our sampling, we noted a compelling trend in the number of mushrooms per plot, with the highest number of specimens consistently found in the 1954 plot followed by the 1936 plot. The 1980 plot showed many less mushrooms, and still less were found in the 1998 plot. The species variation between plots was less noticeable, though the greatest number of species was found in the 1936 plot followed closely by the 1954 plot. We expected the 1936 plot to have the most abundant and diverse mushroom populations, however this was not the case. Though the trend apparent in Graphs 1 seems to support our hypothesis as far as diversity, we did not find statistically significant evidence to support any of the plots as being more or less diverse than any of the others.

The trend in Graph 2 indicates that mushroom abundance was highest in 1954. Again, this was not statistically significant, nor was it predicted in our hypothesis, as we thought the 1936 plot would have more mushrooms. To explain this, we propose that this may correlate to the Intermediate Disturbance Hypothesis, which states that local species diversity is at its greatest with an intermediate level of disturbance; frequently recurring disruptions cause conditions to be harsh, so the more hardy pioneer species dominate, while in ecosystems of infrequent disturbance, climax communities establish, leaving no room for less competitive organisms (Hoopes and Harrison, 1998)

Works Cited

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Appendix

Table 3: Multiple Comparisons – Tukey HSD; Dependent Variable=Shannon

(I) Transects	(J) Transects	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	2	.346694836	.308315322	.680	-.53540142	1.22879109
	3	.233279922	.308315322	.873	-.64881633	1.11537617
	4	.403370432	.308315322	.571	-.47872582	1.28546669
2	1	-.346694836	.308315322	.680	-1.22879109	.53540142
	3	-.113414914	.308315322	.982	-.99551117	.76868134
	4	.056675596	.308315322	.998	-.82542066	.93877185
3	1	-.233279922	.308315322	.873	-1.11537617	.64881633
	2	.113414914	.308315322	.982	-.76868134	.99551117
	4	.170090510	.308315322	.945	-.71200574	1.05218676
4	1	-.403370432	.308315322	.571	-1.28546669	.47872582
	2	-.056675596	.308315322	.998	-.93877185	.82542066
	3	-.170090510	.308315322	.945	-1.05218676	.71200574

Table 4: Multiple Comparisons – Tukey HSD; Dependent Variable=Simpson

(I) Transects	(J) Transects	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	2	-.083738148	.206462902	.977	-.67443261	.50695631
	3	.172478230	.206462902	.837	-.41821623	.76317269
	4	-.112875306	.206462902	.946	-.70356977	.47781915
2	1	.083738148	.206462902	.977	-.50695631	.67443261
	3	.256216378	.206462902	.611	-.33447808	.84691084

	4	-.029137158	.206462902	.999	-.61983162	.56155730
3	1	-.172478230	.206462902	.837	-.76317269	.41821623
	2	-.256216378	.206462902	.611	-.84691084	.33447808
	4	-.285353536	.206462902	.528	-.87604800	.30534092
4	1	.112875306	.206462902	.946	-.47781915	.70356977
	2	.029137158	.206462902	.999	-.56155730	.61983162
	3	.285353536	.206462902	.528	-.30534092	.87604800