Soil Micro-Invertebrate Diversity and Abundance in Early, Mid, and Late Successional Habitats

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ABSTRACT

In southern Vermont, many vertebrate and invertebrate species rely on early successional habitats. I assessed the differences in soil invertebrate abundance and diversity in soil samples taken from early, mid, and late successional habitats, on Hogback Mountain in Marlboro, Vermont. My goal was to find out if successional stage affects invertebrate abundance and diversity. My hypothesis was that successional stage affects organism diversity and abundance. I predicted that there would be a greater invertebrate diversity and abundance in earlier stages of succession. Of all the individuals collected, 64% were found in the early successional habitat. Based on the Shannon-Weiner Index, early successional habitat had the highest diversity. This suggests that early successional habitats may help maintain high invertebrate abundance.

INTRODUCTION

Several species rely on early successional habitats in the northeastern United States. Succession refers to a process of change in an ecosystem that occurs after some disturbance. Historically, natural disturbances included wildfire, beaver activity, storms, and infestation (Askins, 2001). The first stage after a disturbance is called early successional habitat, and is considered vital to the health of surrounding forest communities. The Vermont Natural Resources Conservation Service stated that 10-20% of the forest landscape should be made of old fields, shrublands, and young forest habitats to maintain early successional species diversity (VNRCS, 2007).

Many species rely on early successional habitats, namely birds, bats, and small mammals (Chandler et al., 2012). Several bird species rely specifically on early successional habitats for nesting and feeding, especially grassland birds and shrubland birds, who need large fields and low, thick, woody cover for nesting (NRCS, 2012). The post-fledging portion of the breeding season is the period of time after the young birds fledge from the nest before they migrate. This period can last for two months and is essential for the development of birds.

Several birds move from mature hardwood forest sites to early successional areas for this period of time (King et al., 2006).

Chandler et al. (2012), found that mature forest-nesting birds were more abundant in early successional habitats and that mature forest birds actually prefer early successional habitat during the post-fledging period specifically. They argued that this was due to the abundance and diversity of insect prey found in those habitats (Chandler et al., 2012). For example, invertebrates such as lepidoptera larvae have been found in higher numbers in clearcuts compared to undisturbed mature forests (Keller et al., 2003).

Wilson et al. (2014) compared invertebrate richness, community composition, and biomass in both early and late successional habitats in New Hampshire. They set up insect traps in different stages of growth to collect their data, and found that invertebrate family richness was 1.5 times greater in the early successional areas and invertebrate biomass was 3.2 times greater in the early successional habitat than in late successional habitat. They suggested that including early successional habitat stands in the northeastern managed forest landscapes would help maintain high levels of invertebrate diversity (Wilson et al, 2014).

Human development has prevented many of the natural disturbances that create early successional habitats by restricting forest fires and destroying beaver habitats. More recently, habitat disturbances are becoming anthropogenic. These disturbances include mowing, agriculture, clear-cutting, habitat fragmentation, and pollution (NRCS, 2012). Despite these anthropogenic disturbances, the amount of early successional habitat in most of the northeastern United States is not consistent with the recommended amount to sustain diversity. This could be due to farmland and fields growing into mature forests. Additionally, conservation efforts in North America focus largely on the growth of mature forests and less attention is given to other types of successional stages (Askins, 2001). More recently, some conservation organizations are working to create and maintain certain areas of early successional habitat.

The Hogback Mountain Conservation Association created a ten year plan in which there is planned thinning of forest every two years.

Hogback mountain was once a ski area that operated until 1986 (HMCA, 2005). It is located in the town of Marlboro, in southern Vermont, just north of Route 9. After the ski resort closed, young forest grew on the abandoned slopes creating early successional habitat. Today, these forests are about 30 years old and are no longer early successional areas. In the past few years, about 590 acres were purchased and given to the town of Marlboro to serve as conservation land (USGS, 2010). Certain portions of this land are cut each year to purposefully create early successional habitat.

In order to see if successional stage is related to soil invertebrate diversity and abundance, I analyzed soil samples taken from three different stages in succession from Hogback mountain, by looking at species and number of species in each area. I had two main hypotheses about soil invertebrate diversity and abundance on Hogback mountain: that successional stage would influence the (1) diversity and (2) abundance of soil invertebrates. I predicted that there would be a greater invertebrate density in early successional habitats than in mid and late successional habitats and that there would be a greater overall abundance of micro-invertebrates in the earliest stage of succession than in the later stages of succession.

My research complements that of Wilson et al. (2014) on early successional habitats. It will also support the Hogback Mountain Conservation Association in their efforts to create and maintain early successional growth, much of which is related to attracting birds to the area. Stork et al. (1992) found that soil invertebrates are indicators and determinants of soil quality. They found that invertebrates such as earthworms, termites, springtails, nematodes each determine the quality of soil. So, my research will also assist in determining the quality and health of soil in Hogback Mountain.

MATERIALS & METHODS

To test my hypotheses and predictions, I collected soil samples from three different sites at Hogback mountain. One site was early successional, one site was mid-successional, and one site was late successional. I took three soil samples from each site for a total of nine soil samples. I collected the samples on October 13th, 2015, at about 2:00 pm. The air temperature on Hogback mountain was 61 degrees fahrenheit and there was some drizzling but no heavy rain. I recorded air temperature because most insects either migrate or become dormant as the weather cools in the fall (Schowalter, 2006), and it could be a variable that affects microinvertebrate diversity and abundance.

I used a shovel to dig into the soil about three inches, and put the soil into plastic bags. I collected micro-invertebrates from these soil samples by using funnel traps. I constructed funnel traps by cutting the tops off of plastic bottles and placing the top upside down inside the bottom. I poured an inch of alcohol and water mixture into the bottom of each trap. I placed a screen on the opening of the funnel, and placed each soil sample in the top of a different trap.

After one week passed, I poured the liquid from the bottoms of the traps into petri dishes to observe under a dissecting microscope. I moved the liquid slowly through the lens, and identified different microinvertebrates and recorded how many of each there were in each stage in succession.

I used the Shannon-Weiner Index to analyze diversity and evenness in each successional site that I collected soil samples from. The Shannon-Wiener index (Molles, 2010) is commonly used to measure species diversity and evenness:

$$H' = -\text{sum}(P_i \ln[P_i]) \text{ (natural log)}$$

where:

H' = the value of the Shannon-Weiner diversity index
P_i = the proportion of the *i* th species
natural log = the natural logarithm of P_i
s = the number of species in the community

I chose to use the Shannon-Wiener index because it measures both species richness, or the number of species in a community, as well as species evenness, or how even the number of individual species are (Molles, 2010). Shannon-Weiner Index values can range from 0 to about 4.6. A value closer to zero means that every species in the sample is the same species. A value near 4.6 indicates that the number of individuals is evenly distributed between the species.

RESULTS

Abundance

I captured 47 individuals during the study. Of all the individuals, 27% were fruit flies, which I will include in my data. Fruit flies were found in each stage of succession, but 61% were found in the early successional stage. There was a greater number of individuals overall in the early successional habitat than in both mid and late successional habitats. The least number of individuals were found in the late successional habitat. Of all of the individuals, 64% were found in the early successional area, 21% were found in the mid successional area, and 15% were found in the late successional area (figure 1).

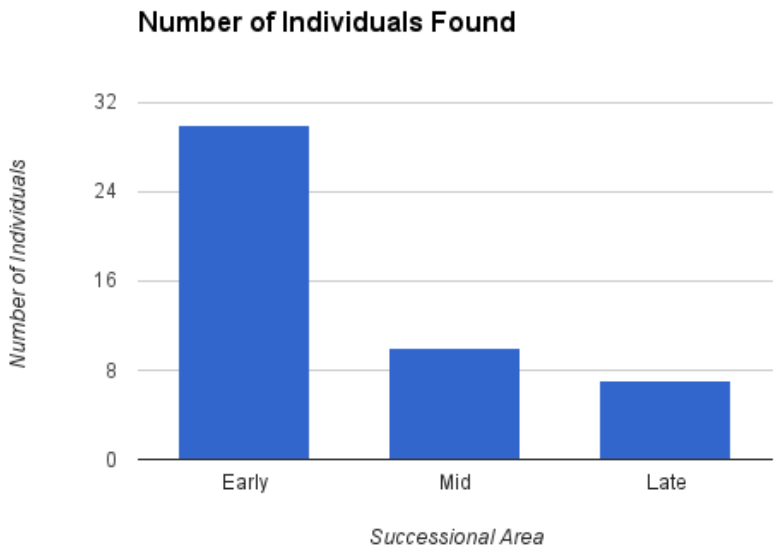

Figure 1. The total number of individual soil micro-invertebrates found in early, mid, and late successional habitat.

Diversity

Out of the 47 individuals I captured, there were 11 different micro-invertebrate types. There was not a large difference in number of species in different successional stages. 9 different types were found in the early successional habitat, 5 types were found in the mid successional habitat, and 6 different types were found in the late successional habitat. While there were a few more types in the early successional habitat, there was not a large difference (figure 2). There was a difference in species diversity among the stages when using the Shannon-Weiner diversity index. The early successional area had an index of 2.6452. The mid successional area had a diversity index of 1.4705, and the late successional area had an index of 1.7469 (see Appendix 2).

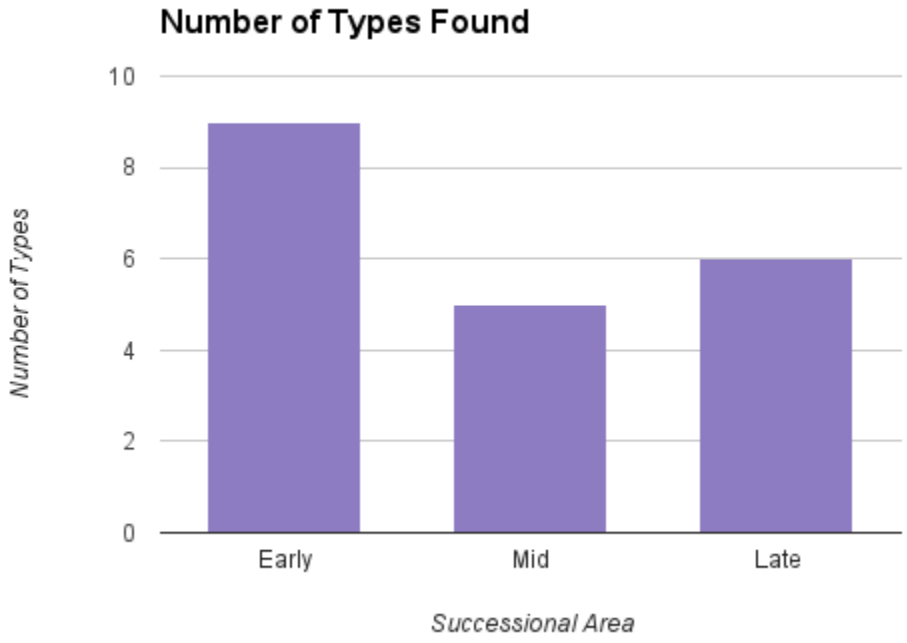

Figure 2. The number of types of soil micro-invertebrates found in each stage of succession.

DISCUSSION

There was a greater abundance of individuals in early successional habitats, and the earliest stage was the most diverse according to the Shannon-Weiner index. These data support my hypotheses and predictions, that there would be greater abundance and greater diversity of soil microinvertebrates in early successional habitats than in mid and late successional habitats.

These data indicate that because macroinvertebrates may be of greater diversity and abundance in earlier successional habitats, invertebrates that live above soil may also be of greater abundance and diversity in earlier successional habitats. This suggests that early successional habitats may help maintain high invertebrate abundance. From these findings, I would also predict that birds and small mammals would have a greater diversity and abundance in early successional habitats because they would be drawn to the food source of abundant invertebrates. My data also suggests that the quality of soil in early successional habitats is very healthy, because of Stork et al.'s finding (1992) that invertebrates are important in determining soil quality.

My results are similar to the results of Wilson et al. (2014), who found that invertebrate family richness and biomass was greater in early successional habitat than in late successional habitat in northern New Hampshire. This study, however, was not looking at soil microinvertebrates but invertebrates above soil. My research could be furthered with studies of soil quality in different stages of succession, to see the nutrients and composition of soil in each stage.

If I were going to repeat this study, I would collect my data much earlier in the year. The best time to collect soil samples would be during warmer months when invertebrates are not dormant. The low temperatures is one possible methodological error. Additionally, the sample sites I chose could have been places that were not representative of the whole areas that I collected data from. To repeat this study I would also construct my traps out of the same size

bottles instead of different sized bottles. I would also place a heat lamp over each trap, to dry out the top of the dirt and ensure that microinvertebrates would fly to the bottom.

This research is important because it suggests that the presence of early successional habitat is important in maintaining diversity and abundance of organisms in an ecosystem. It supports the suggestion of the Vermont Natural Resources Conservation Service (2007) that 10-20% of forest landscape should be composed of old fields, shrubland, and young forest habitats.

APPENDICES

Appendix 1.

Successional Stage	Total individuals	Percent of individuals found
Early	30	64
Mid	10	21
Late	7	15

Appendix 2.

Stage of Succession	List & number of species	Different species found	Shannon-Weiner Index

Early	8 fruit flies 2 mites 1 spider 12 fly larvae 1 millipede 1 unsegmented worm 1 segmented worm 1 sow bug 3 midge larvae	9	2.6452
Mid	4 fruit flies 1 unsegmented worm 1 millipede 2 homoptera 2 segmented worms	5	1.4705
Late	1 fruit fly 1 segmented worm 2 unsegmented worms 1 sow bug 1 coleoptera larvae 1 fly larvae	6	1.7469

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