Decomposition, litter depth, and species richness across four seral stages of a temperate deciduous forest

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Abstract
Secondary succession is the re-growth of a disturbed community and can take a long time, especially in temperate forests. Species diversity, biomass, and stability usually increase throughout succession. This experiment was carried out in four seral stage, Old Field, Pine Forest, Late-Transitional, and Climax at the Rice Center in order to determine decomposition, litter depth, and species richness. Species richness did not increase over time, instead it decreased, while, biomass did increase over time. Many factors such as the idea of certain plants inhibiting or stimulating the growth of other plants was not investigated in this experiment and could explain a disparity in the results.

Introduction
Secondary succession occurs when a community is disturbed by, for example, a forest fire, but the soil is not destroyed (Molles 2002). Succession in temperate forests takes hundreds of years to complete (Molles 2002). Succession ends in a climax community, in which the community is stable until it is disrupted (Molles 2002).

In 1950, Catherine Keever conducted a study on the old fields of the Piedmont Plateau in North Carolina (1983). She found that generally the first species to colonize and dominate the recently disturbed fields were Crabgrass, *Digitaria sanguinalis*, and then followed by horseweed, *Erigeron canadense* (1983). The second year of succession, the fields were dominated by aster, *Aster pilosis* (1983). A few years later, the fields were dominated by broomsedge, *Andropogon virginicus* (1983).

Another study was done on the old fields of the Piedmont Plateau in Georgia by David Johnston and Eugene Odum in 1942 (1956). They found that a few years after the old fields were covered in broomsedge, pine seedlings appeared and formed a closed canopy in 10 to 15 years (1956). In 40 to 50 years, the pine forests have a well-developed understory of young deciduous trees, usually oak, *Quercus*, and *Carya*, hickory (1956). The deciduous trees become dominant by about 150 years because they can grow in each others shade, but pine trees cannot, therefore the late successional oak-hickory forest becomes the climax stage (1956).

Bormann, Likens, Pierce, and Reiners did an experiment that looked at the recovery of nutrient retention after a disturbance (1978). They divided the recovery of a forest ecosystem from disturbance into four phases (1978). Phase one is a reorganization phase of 10 to 20 years in which the forest loses biomass and nutrients despite the fact that it is still accumulating biomass (1978). Phase two is the aggradation phase which takes a century or more and the forest reaches a peak biomass (1978). Phase three is the transition phase in which biomass declines and phase four is when biomass reaches a steady level (1978).
The objective of this study was to compare four seral stages, which were Old Field, Pine Forest, Late-Transitional, and Climax to each other in terms of decomposition, litter, depth, and species richness (*null and alternate hypothesis in appendix).

Methods

This experiment was carried out at the Rice Center in four different seral stages. The four seral stages were Old Field, Pine Field, Late-Transitional, and Climax.
Each seral stage was allocated a study site and within the study site a decomposition experiment, soil analysis, and vegetation sampling were completed. The soil analysis was conducted by measuring the depth of the litter layer with a ruler from 10 different sites within the seral stage. A soil pit was dug with a shovel to a depth of at least 20 inches and the soil was examined for horizons. The thickness of each horizon was measured with a ruler within each pit.
The vegetation sampling was performed by randomly separating the study site into three circular plots. A flag was put in the center of each circular plot and a tape measure was used to put four other flags 10.5 m away from the central flag in the four cardinal directions. All the plant species in the three circular plots were identified with a vegetation identification key and written on vegetation data sheets. The vegetation data sheets were split into five different categories. The categories were trees with a DBH greater than or equal to 5.0 inches and 20 feet tall or more, saplings with a DBH greater than 0.4 inches but less than 5.0 inches and 20 feet tall or more, shrubs about 3 to 20 ft tall that included multi-stemmed, bushy shrubs, small trees or seedlings, woody vines, and herbaceous plants that included grasses, sedges, rushes, forbs, ferns, and tree seedlings.

The decomposition experiment was conducted by labeling, weighing, and randomly placing 10 bags full of leaf litter within each study site. The bags were collected about three months later and re-weighed for litter mass loss.
Analysis of species richness, litter mass loss, and litter depth, (ANOVA; $\alpha = 0.05$) were performed to compare the four seral stages.

Results

The Old Field had the most species in its three circular plots (Table 1). Climax had the least amount of species in its three circular plots (Table 1). The Pine Forest and The Late-Transitional had no E horizons, but all four seral stages had B horizons (Table 2). The Climax had the thickest horizons and the Old Field had the second thickest horizons (Table 2). Species richness was highest in the Old Field (30.6 ± 4.7) and lowest in the Climax (11.6 ± 2.6) (Figure 1). Significant differences for species richness were seen between the Old Field, Late-Transitional and Climax (Figure 1). No significant differences for species richness were seen between Old Field and Pine Forest (Figure 1). Litter depth was highest in the Pine Forest (3.3 ± 0.169) and lowest in the Old Field (1.41 ± 0.332) (Figure 2). Significant differences for litter depth were seen between Old Field and Pine Forest (Figure 2). No significant differences were seen for litter depth between Late-Transitional and Old Field and no differences between Climax, Old Field, Pine Forest, and Late-Transitional (Figure 2). Percent mass remaining was highest in the Climax (55.59 ± 4.43) and lowest in the Pine Forest (44.4 ± 0.991) (Figure 3). Significant differences were seen for percent mass remaining between Pine Forest and all the other seral stages (Figure 3). No significant differences were seen between Old Field, Late-Transitional, and Climax (Figure 3).

Discussion

The proportion of species lost over time should decrease as the community approaches equilibrium (Shugart et al. 1973). On the other hand, species diversity, structural complexity, biomass, and stability should increase over time (Shugart et al. 1973). For this study, however, the amount of species lost over time increased as the community approached equilibrium (Table 1). Species richness was highest in the Old Field, while it should have been highest in the Climax (Figure 1). Litter depth was highest in the Pine

Forest, while it should have been highest in the Climax (Figure 2). Percent mass remaining was highest in the Climax as it was supposed to be (Figure 3). Thus, only percent mass remaining or biomass followed the general trend (Figure 3).

The results did follow the data found by Bormann, Likens, Pierce, and Reiners for nutrient retention or biomass did increase over time (Figure 3). The results also followed the data found by Keever, Odum, and Johnston for the Old Field did have the most herbaceous species and few vines and saplings (Table 1). Also the amount of pine trees did decrease over time to a larger amount of deciduous trees (Table 1).

It is possible that the time of invasion of different plants affected the success of herbaceous plants (Rankin et al. 1989). This could explain the high amount of herbaceous plants in the Old Field and woody/tree species (Table 1). Keever's experiments showed that Horseweed inhibits the growth of Aster and that Aster stimulates the growth of broomsedge (1983). It is possible then that some of the herbaceous plants in the Old Field stimulate the growth of woody/tree species.

The overall purpose of this paper was to show the function of forested ecosystems based on how old it is. This was aptly shown by this experiment even with the discrepancies in the data for a lot of factors such as what plants inhibit and stimulate different plants was not taken into account.

*Appendix:

1) There is no significant difference in species richness between the four seral stages.
There is a significant difference in species richness between the four seral stages.

2) There is no significant difference in litter depth between the four seral stages.
There is a significant difference in litter depth between the four seral stages.

3) There no significant difference in percent mass remaining between the four seral stages.
There is a significant difference in percent mass remaining between the four seral stages.

Literature Cited

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