Effects of age on hummock succession in bogs

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Abstract

Ecological succession is the change in communities over time. We chose to study the successional stages of hummocks in a bog using age. We hypothesized that hummock plant richness should increase then decrease with age because of successional flora species mixing. We also hypothesized that hummock density, and hummock size will increase with age. Our study site was a bog at Mud Lake located in Cheboygan County, Michigan. We set up two 100 meter transects, divided them into zones based on age then recorded hummock surface area and hummock density. Plant richness was also recorded.

There was a significant difference in plant richness with hummock age but only when surface area was used a covariant. Surface area was not significantly different among different aged zones. Hummock density did not have any correlation with age. Places were successional flora species mixed provided more plant richness and also showed trends of higher surface area. The tree line altered our results in the youngest zones because it had late successional species mixed with early successional species. This gave one of our youngest zones the highest plant richness. This shows that trends exist between hummock size, and plant richness but the surrounding morphology has a large impact.

Introduction

Succession within an ecological community is the change in species composition over time. This can change the biodiversity of the environment by altering conditions making it more adaptable by other species (Katz, 1926). This can be seen in the classic hydrosere succession model, where infilling of a shallow lake by sediments produces a sequential trend of vegetation communities staring with marsh shrub and moss species and ending with climax forests composed mostly of woody species (Klinger, 1996).

Bogs are wetlands formed by large depressions in the land (usually from glaciers) filling up with precipitation making them acidic. Over time ecological succession causes vegetation to invade the lake. The highly acidic waters make decomposition very slow and the partially decomposed matter fills up the ombotrophic Lake creating a floating mat (Gore, 1983). The presence of *Sphagnum spp.* also attributes to the acidic waters because it absorbs metal ions and inputs hydrogen ions (Dodds and Whiles, 2010). These peat mats (*Sphagnum spp.*) on top of the decaying matter promote anaerobic conditions making decomposition rates even slower (Clymo, 1978). The decomposing matter progresses further into the lake. Over a long period the lake will eventually fill in. Therefore, the distance from open water can be used as a metric to estimate the relative age of areas on the peat mat. The areas near open water have the youngest peat mat formations, and age increases with distance.

Within bogs there are areas called hummocks that have higher elevation and sit above the water table. These hummocks combined with the lower lying hollows create bog micro-topography which is specific to certain types of species. Hummocks are predominantly made up of *Sphagnum spp.* and usually have woody plants and forb species. Some woody species that are common in bogs, such as tamarack (*Larix laricina*), can provide structure and support for underlying *Sphagnum spp* to grow (Breeman, 1995). The root systems created by these woody species penetrate the acrotelm, the top layer of undisturbed peat. As a consequence, the hummocks grow in height relative to the hollow areas were they lack adequate support (Malmer & Wallen, 1999). Thus, woody species can increase the input of atmospheric solutes, such as nitrogen, into hummocks providing more nutrients allowing for increased plant growth (Clymo et al., 1990).

The purpose of our study was to use hummocks observe and understand factors affecting succession in bogs using hummocks. We hypothesized that hummock plant richness will increase than decrease with hummock age because of the mixing of successional stages of bog vegetation. We also hypothesized that hummock density would increase with age because greater woody species will be present on the forest edge giving more support for hummock formation, finally we hypothesized that hummock size will increase with age because they had more time to form. To test these hypotheses we sampled hummocks of different ages at Mud Lake Bog.

Methods & Procedures

Our study was conducted at the floating peat mat called Mud Lake Bog located Mud Lake, Cheboygan Co., Michigan (N45.022°, W85.175°).The bog mat consists of two hummock and hollow areas which are divided by a tree line near the open water. A forest surrounds the entirety of the peat covered area of Mud Lake Bog. The newest part of the peat mat is located at the center and encroaches on Mud Lake; age of peat increases with distance from open water (Figure 1).

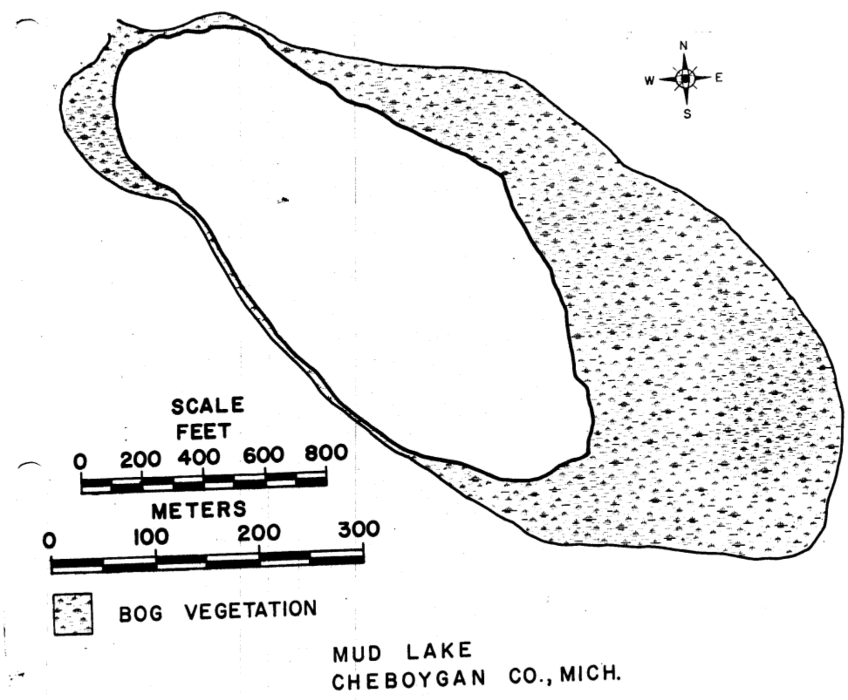

Figure 1: Diagram of Mud Lake Bog peat mat and open water. Created by RANN project at UMBS 1972-1975

Sampling extended from the tree line (Sample Start) to the forest edge (Sample End). Our sample area was 5 m wide and was divided into 10, 9.3- meter long zone. Each zone represented an age class of peat formation; with zone one being nearest open water and representing the youngest age group. Two sampling areas were used and then combined in order to provide adequate samples of hummock density, size, and distribution.

To document any correlations between hummock size distribution and the hummocks' distance from open water, we recorded diameter, height, and zone number for every hummock in each of the two sampling areas. Hummocks less than 10 cm in height and 20 cm in diameter were excluded because we did not consider them to be fully developed hummocks.

To document any relationship between vegetation succession and bog age, we sampled three randomly chosen hummocks in each zone of transect 1 and identified plant species present as well as their percent cover. We measured the height of the tallest woody plant on each of the three hummocks.

We used linear regression analysis to evaluate correlations between hummock height with diameter and hummock density with age. We used an ANOVA to determine if there were any significant differences in hummock age with mean hummock surface area when transects were combined. We also used an ANCOVA to determine if there was a significant difference in plant richness with hummock age with a covariate of mean hummock surface area.

Results

Plant richness did not change among zones ($F=2.301$, $df=29$, $p= 0.058$). However, when surface area was taken into account mean plant richness was significantly different among different age zones ($F=2.885$, $df= 29$, $p=0.025$, covariate $p=0.011$; Fig. 1). Plant richness ranged from 16 species in zone 1 to 9 species in zones 2, 3, 4,7,10.

We found no correlation between hummock density among zones ($F=0.022$, $df=9$, $r^2=0.039$, $p=0.885$; Fig. 2) The average number of hummocks found in each zone was 15 and ranged from 8 to 23. Zone 3 had the highest number of hummocks with 23 and zone 6 had the lowest with 8.

No significant difference in hummock surface area was found among zones ($F=1.206$, $df=9$, $p=0.296$; Fig 3). The average surface area of hummocks showed a trend with increasing age, but the high variance made it difficult to draw further conclusions. The average hummock surface area was 1.61 m^2. The hummock with the highest surface area was in zone 10 with 10.8376 m^2, and the lowest was in zone 3 with .1699 m^2. Zone 6 had the highest range of hummock surface areas with the highest hummock being 9.7907 m^2 and the lowest being 0.3460 m^2. This led to high variation within zone 6. There was also a positive linear relationship between height and diameter showing regularity in hummock shape ($r^2=.361$, $p<0.001$; Fig.4).

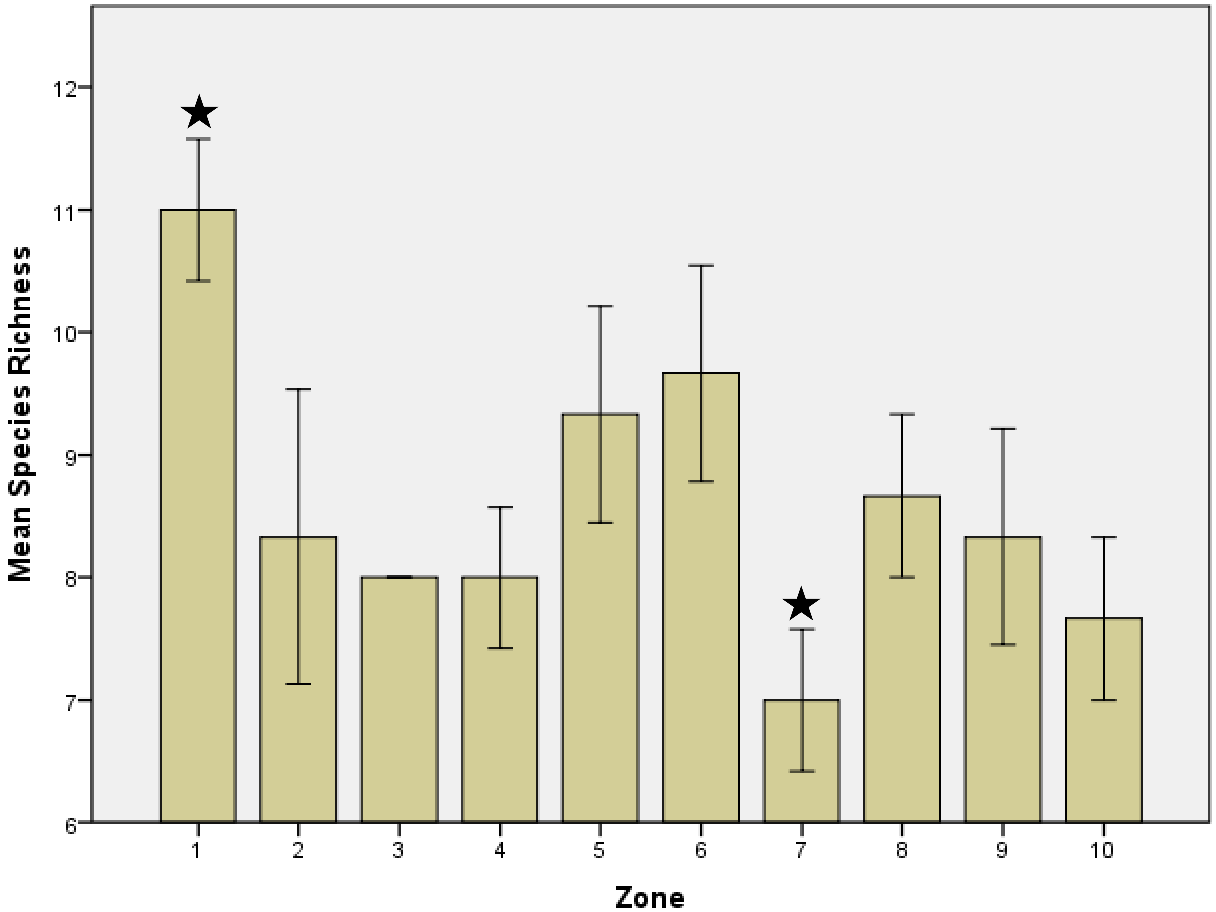

Fig. 1 Mean plant richness in each zone. There was a significant effect of zone on plant richness (p=0.025). Stars indicate a significant difference in Tukey test (p=0.032)

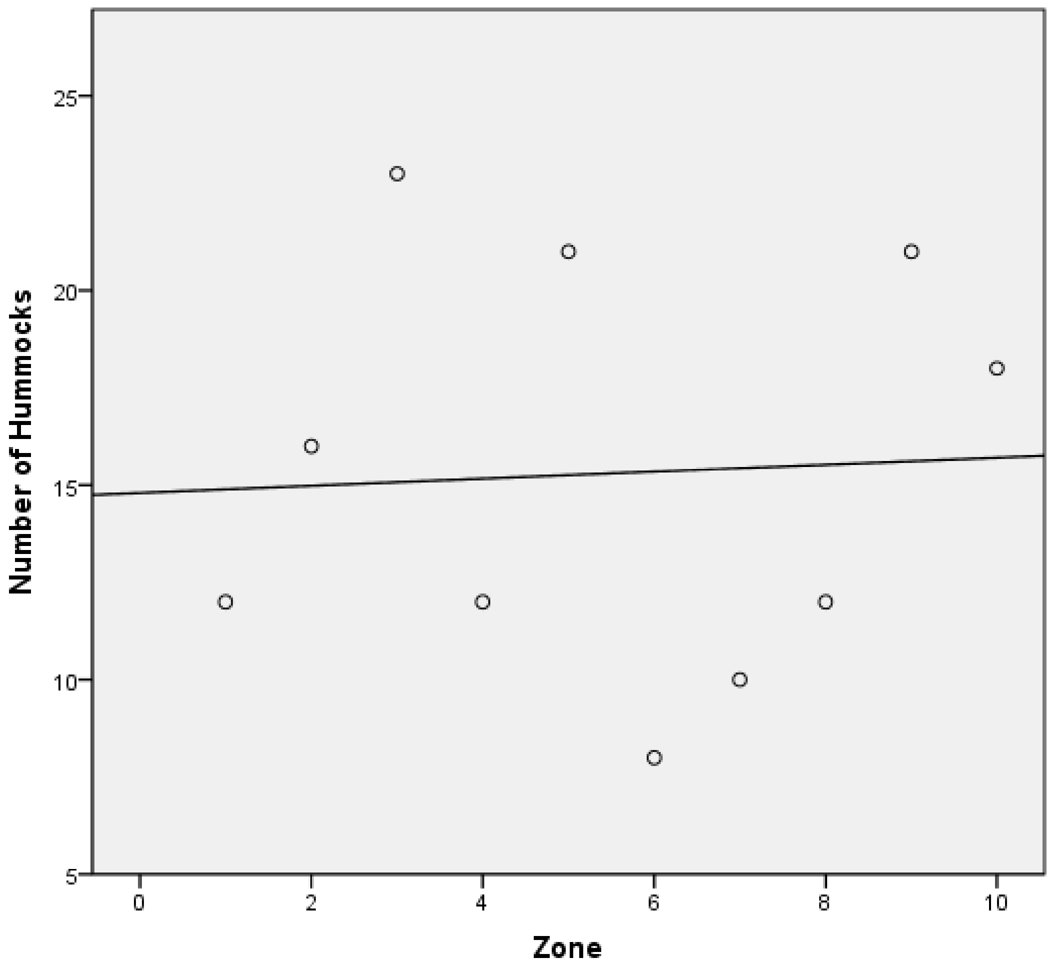

Fig. 2 Number of hummocks in relation to zone. (r^2=0.039, p=0.993)

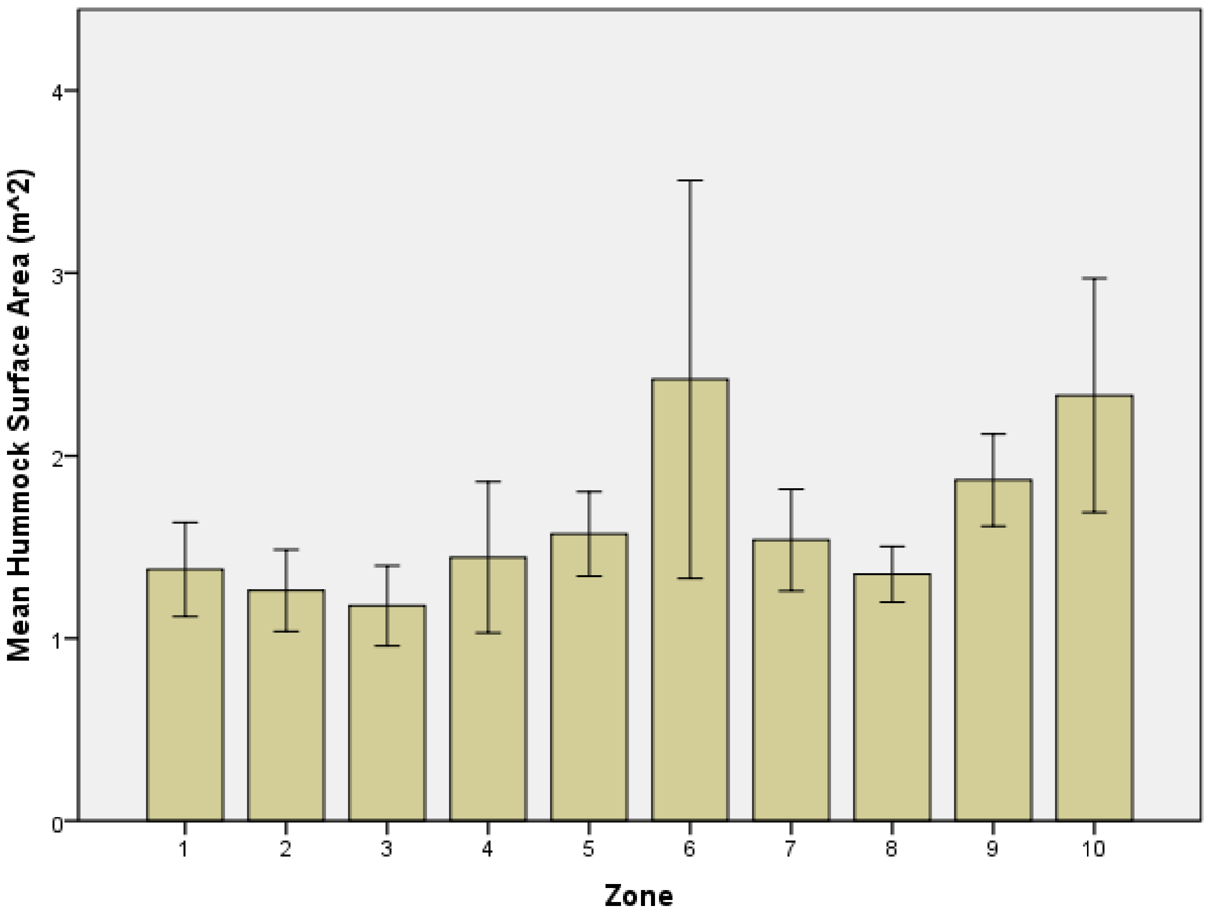

Fig. 3 Mean hummock surface area (m^2) in each zone. There was no significant effect of zone on hummock surface area ($p=0.296$)

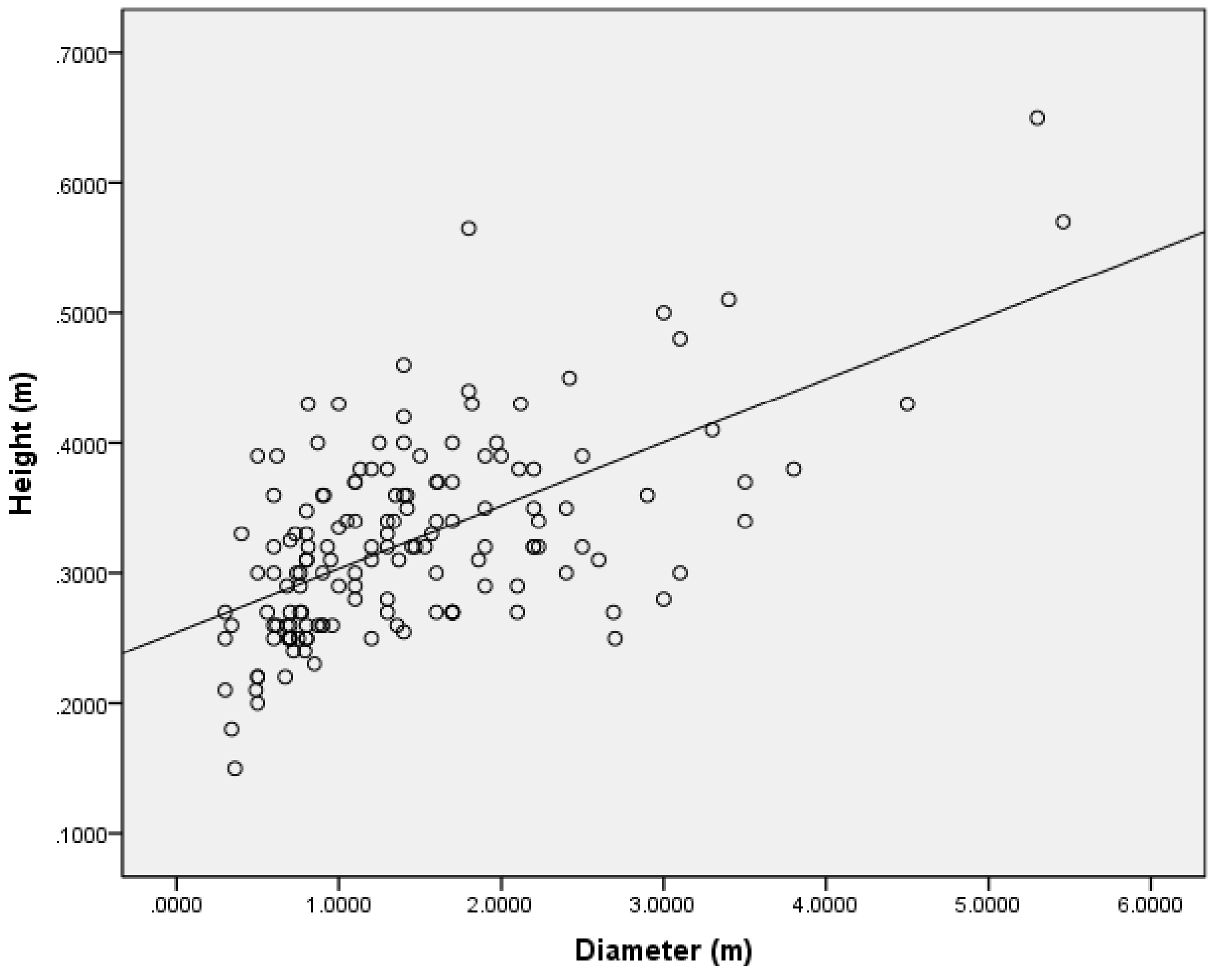

Fig. 4 Hummock height in relation to hummock diameter (r^2= 0.361, $p<0.001$).

Discussion

Our data showed a significant effect of zone on plant richness. There was a significant difference in plant richness with zone when surface area was taken into account. Since increasing zone number denotes increasing age, we can say that there was significant difference in plant richness with hummock age. Plant richness had high variability with age but followed an overall decreasing trend. We choose surface area as a covariant because hummocks are more exposed to aerobic conditions, and greater surface areas allow for more species to grow (Hogg, 1993). We found that plant richness was high in young areas of the bog which could be explained by the morphology of Mud Lake bog. Near the edge of Mud Lake there is a line of thick vegetation consisting mostly of *Sphagnum spp.*, black spruce (*Picea mariana)* and tamarack (*Larix laricina).* This line of vegetation is formed by an accumulation of sediment from wave motion created wind at Mud Lake. The increased vegetation provides protection from overhead winds and allows for greater amounts of sediment deposition. The sediment allows for greater nutrient retention and structure for the common woody species found there (Anderson and Mitsch, 2006). Therefore, the tree line allows for more successional stage mixing giving our youngest zones the highest number of species. The increase in plant richness in zones 5 and 6, along with the following decrease in later zones shows the mixing of mid and late successional stages. Zones 1 and 7 were significantly different because they had the highest and lowest plant richness respectfully. Even though plant richness was significantly different hummock age with addition of surface area as a covariate, we found that plant richness was more dependent on successional period rather than surface area in our study.

We found that hummock density does not correspond to age. The spatial distribution of hummocks seemed to occur at random. The presence of woody species could explain the presence of hummocks because they provide greater support for sphagnum accumulation. However, we found some hummocks without a woody species present. This can be explained by *Sphagnum spp.* ability to use dead tissue to out compete other species. Instead of using this tissue to climb above other species, it covers their roots first and grows over them. This may explain why we found random spatial distribution among hummocks because they do not depend solely on the structure of woody species for growth but on many other factors such as nutrient content and amount of sunlight (Breeman, 1995).

Our data also shows that there was no significant difference in mean hummock surface area with hummock age. Zones 6 in transect 2 showed a large increase in mean hummock surface area but the large variance can be explained by two highly varying hummock surface areas.

We can conclude that plant richness was significantly different with hummock age and average surface area. The mixing of flora found in different successional stages explains the fluctuations plant richness. The tree line found on the edge of Mud Lake formed by increased sediment deposition could provide more structure for hummock formation allowing for increased surface area leading to greater plant richness (MacArthur, 2008). The accumulated sediment also holds greater nutrient content than the decaying peat found farther from Mud Lake.

Successions within bogs can be seen as a classic hydrosere model where a body of freshwater is filled in with aquatic vegetation leading to climax communities of woody species. However, there are many physical factors that determine what species succeed others and at what rates it occurs. We found that hummock age had a significant effect on plant richness when we used a covariate of surface area. We did not observe any significant effect of age on hummock density or surface area alone. These observations show trends in bog succession but many other variables, such as physical or chemical variations, must be taken into account to fully understand the transitions between successional stages.

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