Successional changes in arthropod communities at the University of Michigan burn plots

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8/14/12

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Abstract. The purpose of our study was to identify the effects of successional changes on arthropod communities over a large ecological timescale. We hypothesized that as succession progresses, plant species richness would increase and eventually decrease and that arthropod species richness would follow a similar pattern. We predicted that the effects of succession would affect ground-dwelling species more than non-ground species. We also expected that a greater abundance of arthropods would be present with higher plant species richness. Four burn plots were selected (1911, 1948, 1980, and 1998) within the University of Michigan Biological Station property. Within each plot, pitfall traps, flight interception traps, and sweep samples were used to collect arthropods. Three total samples were sorted to order.

There was a significant difference in the number of plant species among the burn plots. There was also a significant difference in the number of arthropod taxa and arthropod abundance among the seral stages. Arthropod richness followed the same pattern as plant species richness. Non-ground taxa captured in flight interception traps and sweep samples showed no trend among the different-aged stands. The abundance of arthropods was largest in the same plot that the number of plant species was highest. Ground arthropods were heavily influenced by succession while non-ground species seemed less affected. Impacts to forests like logging and fire have significant consequences on plant and arthropod communities.

INTRODUCTION

As succession progresses over time, structural biomass and ecosystem diversity increase (Brown and Southwood 1983). Studies show that the resulting increases in resources support a greater number of animal species (Siemann et al. 1998). Over time, different plant and animal species occupy the area and establish unique ecosystems. It is well documented that overall growth will eventually climax and level off (Odum 1969). Johnston and Odum (1956) found that the number of species of breeding birds directly followed the community development of a forest on the Georgia Piedmont.

Previous experiments that have followed post-fire chronosequences have shown growth in arthropod richness as forests age (Force 1981; McCullough et al. 1998; Buddle et al. 2006). Southwood et al. (1979) found a direct correlation between plant succession and arthropod succession. An increase in plant species diversity and richness positively influenced arthropod species composition (Brown 1985). Smith (1928) found that certain arthropod orders, such as Orthoptera, arrive at early stages of forest succession while others, like Collembola, arrive late in succession.

The purpose of our study was to identify the effects that successional changes have on arthropod communities over a large ecological timescale (approximately 100 years). We predicted that as community age increases, plant species richness would increase and later decrease and arthropod richness would do the same. We hypothesized that the change with succession in richness of arthropods living on the ground would be greater than that of non-ground taxa since flying arthropods are able to move among the habitat more easily. We predicted that there would be a higher density of arthropods prevalent when there was greater plant species richness. To test these predictions we evaluated the differences in arthropod samples found in pitfall traps, sweep nets, and flight interception traps placed within a post-fire chronosequence at the University of Michigan Biological Station (UMBS) burn plots.

METHODS

The study was conducted between July 24 and July 31, 2012 in four of the UMBS burn plots in Pellston, MI (Cheboygan County). The plots were burned in 1911, 1948, 1980, and 1998. Each plot was roughly 100m x 100m in size (Fig. 1). Soil in the plots ranged from dry-mesic to wet-mesic conditions. A steady replacement of *Populus grandidentata* by *Pinus strobus* was commonly observed throughout each plot (Roberts and Richardson 1985).

We sampled within a 30m x 30m area at the center of each of the four burn plots to avoid edge effects. The 1998 sample area was slightly smaller (30m x 10m) due to restricted areas within the site. Four pitfall traps (Fig. 2) filled with approximately 125mL of propylene glycol were installed at the corners of each area. Three flight interception traps (Fig. 3) filled with a similar amount of propylene glycol were installed at random within each 30m x 30m plot as well. Traps were checked for samples every third day over the course of the study. On the final day, three sweep net samples were taken at random along a 10m transect within each area. After three samples were collected, the arthropods were identified to order. We sampled a 1m x 1m quadrat around every pitfall trap to determine understory plant species richness.

Three one-way ANOVAs were used to determine if there was a difference in plant species richness, arthropod species richness, and arthropod abundance among different-aged stands. All three samples from each individual pitfall trap were combined. Due to spatial variation in the flight interception traps and sweep samples, there were no replicates and only descriptive statistics were provided.

RESULTS

We sampled 548 arthropods and identified 98 different taxonomic units from 10 unique orders. Arthropods from the orders Hymenoptera, Diptera, Arachnida, and Coleoptera contained the largest number of individuals among the four burn plots (Fig. 4). Approximately 33% of all arthropods collected were of the order Hymenoptera, and another 22% were Diptera.

There was a significant difference in the number of plant species found in each burn plot ($F = 3.541$; $df = 3,12$; $p = 0.048$; Fig. 5). Plant species richness increased by nearly 62% from the 1998 plot to the 1948 plot. The increase in richness continued until the 1948 plot and then decreased marginally by around 6% to the 1911 site. There was also a significant difference in the number of arthropod taxa collected among the seral stages (F = 6.286; df = 3,12; p = 0.008; Fig. 6). Arthropod richness nearly doubled from the 1998 to 1980 plot. Richness peaked in the 1980 plot and slowly diminished until an eventual 33% decrease from the 1948 to 1911 plot.

Although no statistical analysis could be used on the flight interception and sweep sample collections, the data showed no obvious trend (Fig. 7). There was a 39% decrease in richness in flight interception traps and a 22% decrease in sweep samples from the 1998 to 1980 plot. From the 1980 to 1948 plot, species richness rose nearly 30% in flight interception traps and approximately 39% in sweep samples.

There was a significant difference in the abundance of ground-dwelling arthropods among burn plots (F = 8.044; df = 3,12; p = 0.003; Fig. 8). The number of arthropods in the 1980 plot was five times larger than in the 1998 plot. Abundance diminished by half from the 1980 to 1948 plot and half again from the 1948 to 1911 plot. Abundance within arthropod order, namely Hymenoptera, increased almost 4.5 times from the 1998 to 1980 plot and then decreased 42% from the 1980 to 1948 plot (Fig. 4). The large peak of Hymenoptera in the 1980 plot was mainly due to ants.

Discussion

There was a significant increase followed by decrease in both plant and arthropod richness. Similarly, Southwood et al. (1979) found that there was a similar trend in a typical old-field to oak-birch woodland succession. Richness increased until a mid-successional stage, such as the 1980 and 1948 burn plots, and then decreased in the late-successional stage like the 1911 plot. This may have been due to the increase and subsequent decrease in structural diversity of green plants (Southwood 1979). Siemann et al. (1998) found that plant succession directly facilitated arthropod succession in a Minnesota grassland. In agreement with Smith (1928), we also saw certain arthropod orders arrive at different stages in forest succession. Collembola was not found at the 1998 site, but arrived later in the mid to late-successional stages. Homoptera was not found in the 1911 plot, however resides in the early to mid-successional areas. According to Coley (1983), younger plants, such as early successional species, tend to be more nutritious and less tough. This may be why plant-sucking orders like Homoptera find these seral stages more desirable.

There was clearly no trend between the ground arthropod species and the non-ground species caught in flight interception traps and sweep samples. Arthropods caught in the flight interception traps and sweep samples might have been more prone to flying among different-aged stands, which were approximately 50m apart from one another. Ground-dwelling arthropods were more influenced by successional effects.

Our data supported our hypothesis that a larger abundance of arthropods would occupy plots with greater plant species richness. Arthropod abundance increased quickly, peaked at the 1980 plot, and subsequently decreased following the trend seen in plant species richness. The largest number of arthropods and unique plant species were both found at the 1980 site. This was seen particularly in Hymenoptera abundance (namely, ants) in the 1980 plot.

Successional changes within forests have significant effects on arthropod richness. The trend that arthropod richness directly followed plant species richness was not unique to this study. Insects above the ground were not affected by changes in succession, which provides an interesting contrast. However, it was clear that ground arthropod species are heavily influenced by plant succession within forests. Disturbances to forests such as clear-cutting and fire have substantial impacts on both plant and arthropod communities.

ACKNOWLEDGMENTS

We thank C. Bach and K. Uthus for insight, comments, and assistance; S. Webster for supplying pitfall traps, sweep nets, and flags; B. Sholtens for insight and access to flight interception traps; B. Vande Kopple for information and access to the UMBS burn plots; and A. Auclerc for assistance in the field.

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APPENDIX

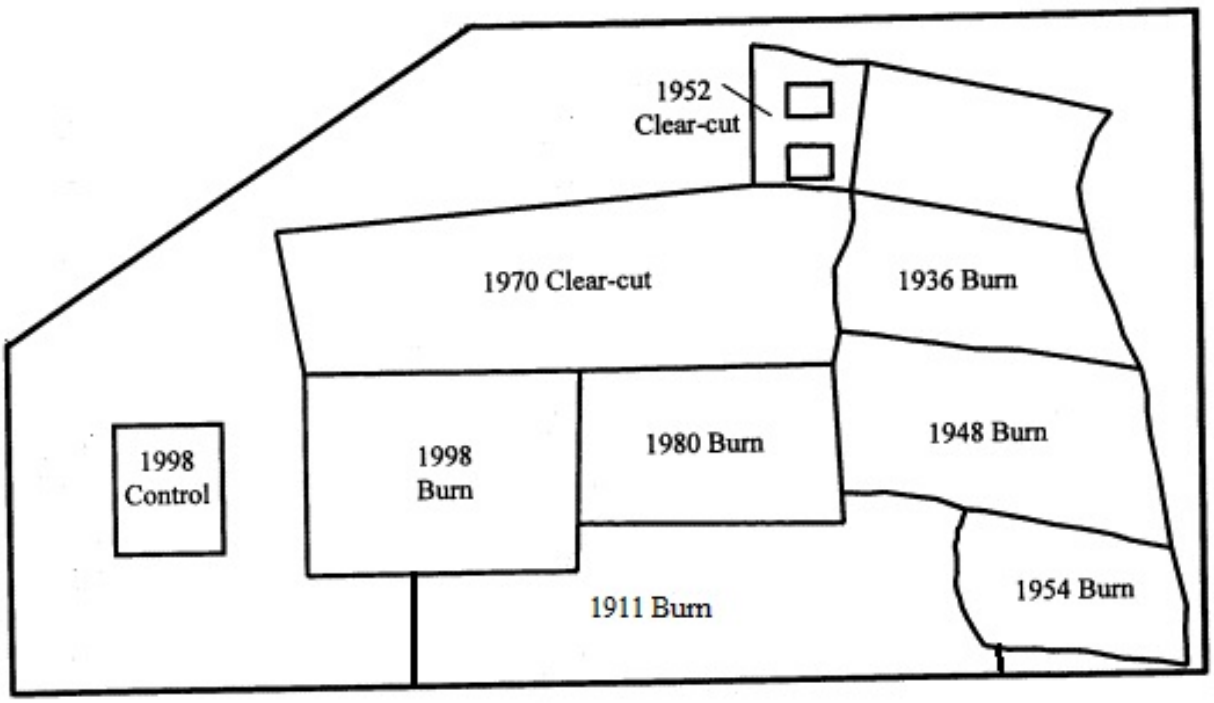

FIG. 1. Diagram illustrating the arrangement of the burn chronosequence at the University of Michigan Biological Station (UMBS), Cheboygan Co.

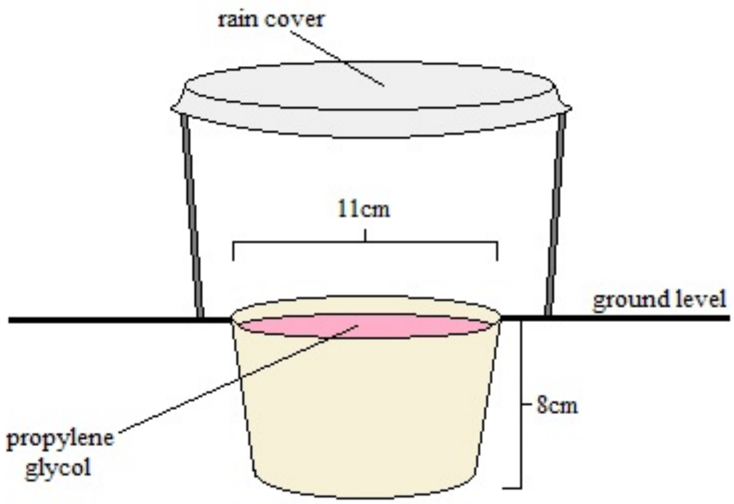

FIG. 2. Diagram of pitfall trap with rain cover.

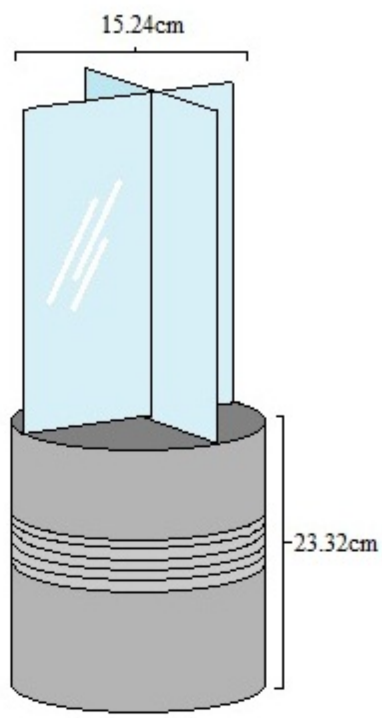

FIG. 3. Diagram of flight interception trap.

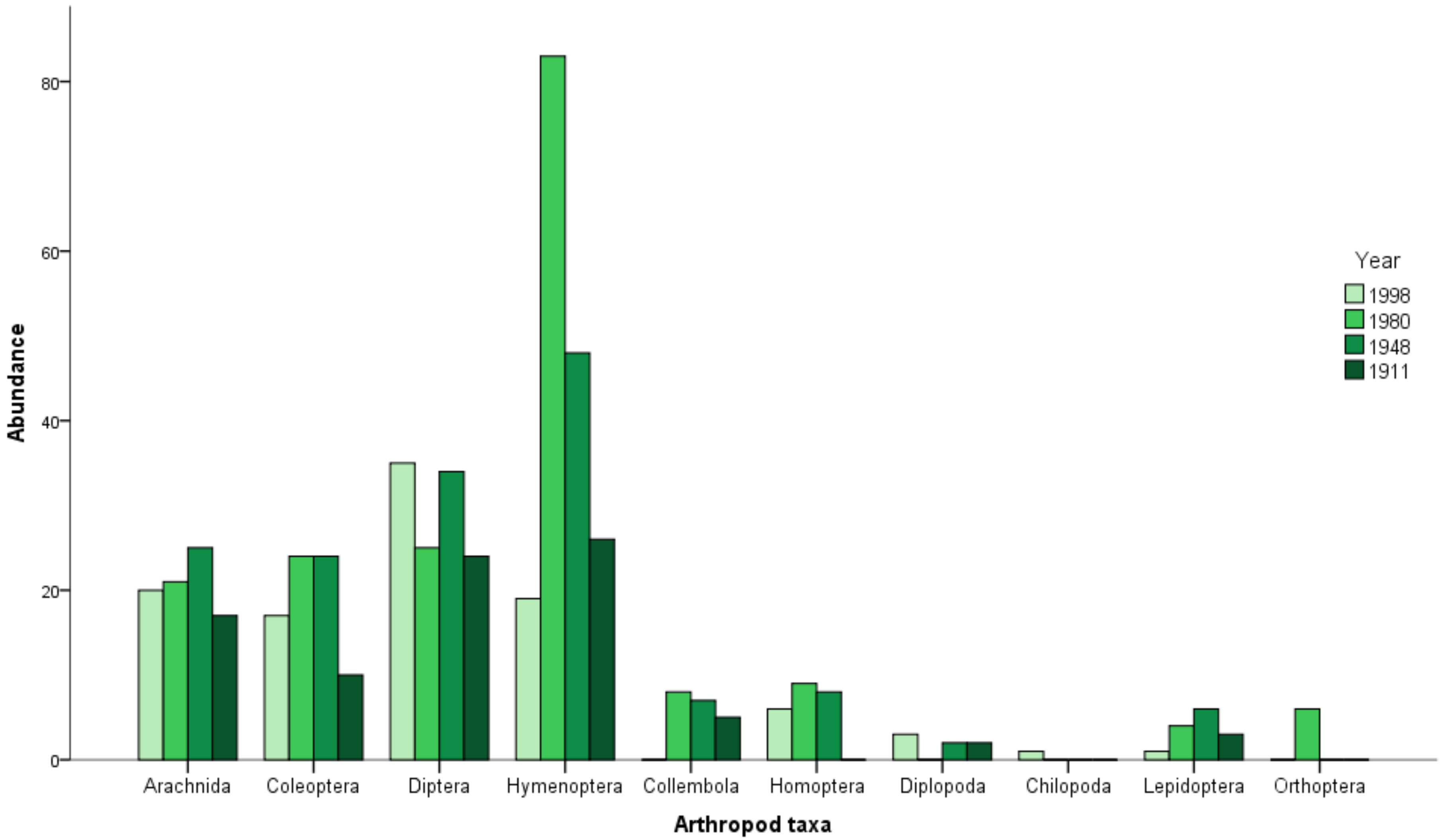

FIG. 4. Abundance of all arthropod orders in pitfall traps, flight interception traps, and sweep samples found at the UMBS burn plots.

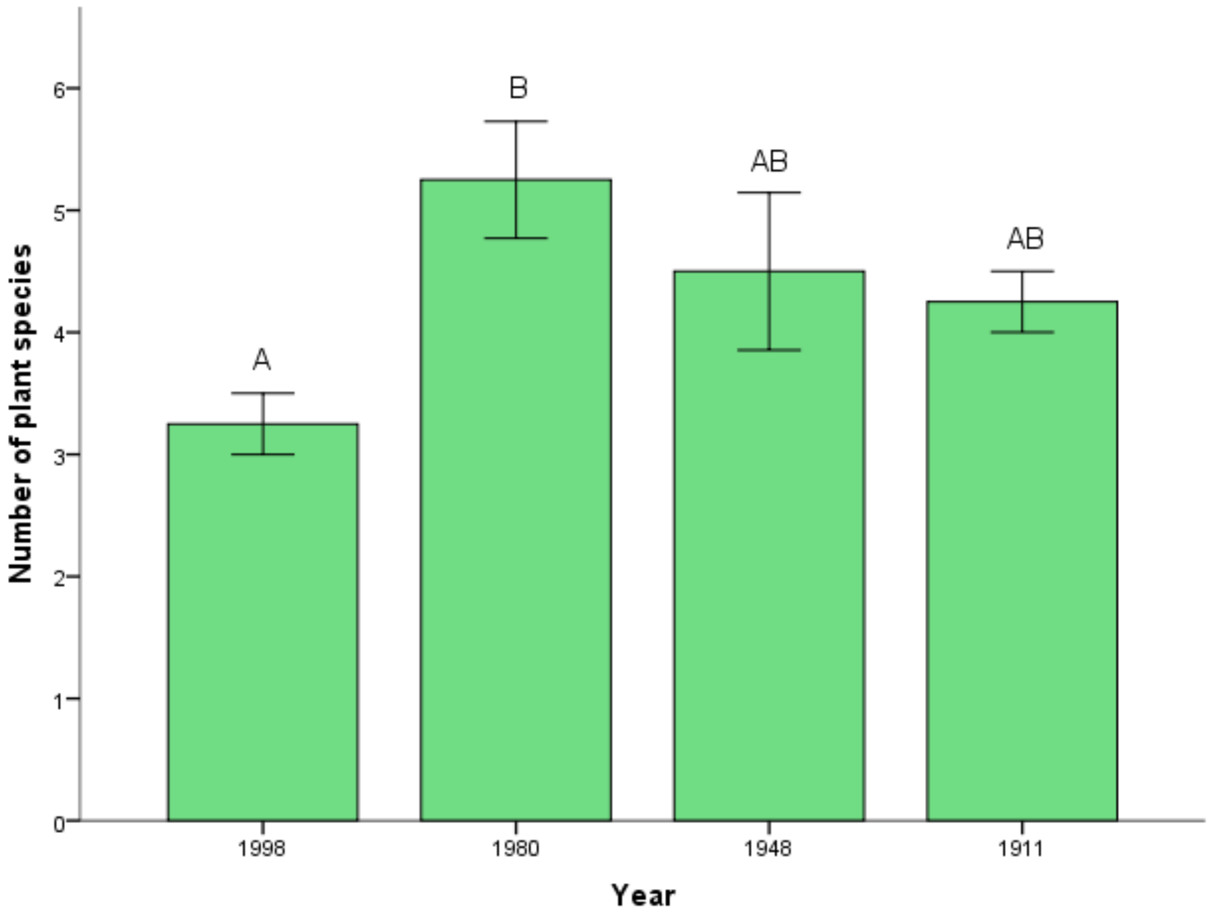

FIG. 5. Mean (+SE) number of plant species across four different aged stands at the UMBS chronosequence burn plots (p = 0.048). Letters represent pairwise differences among years.

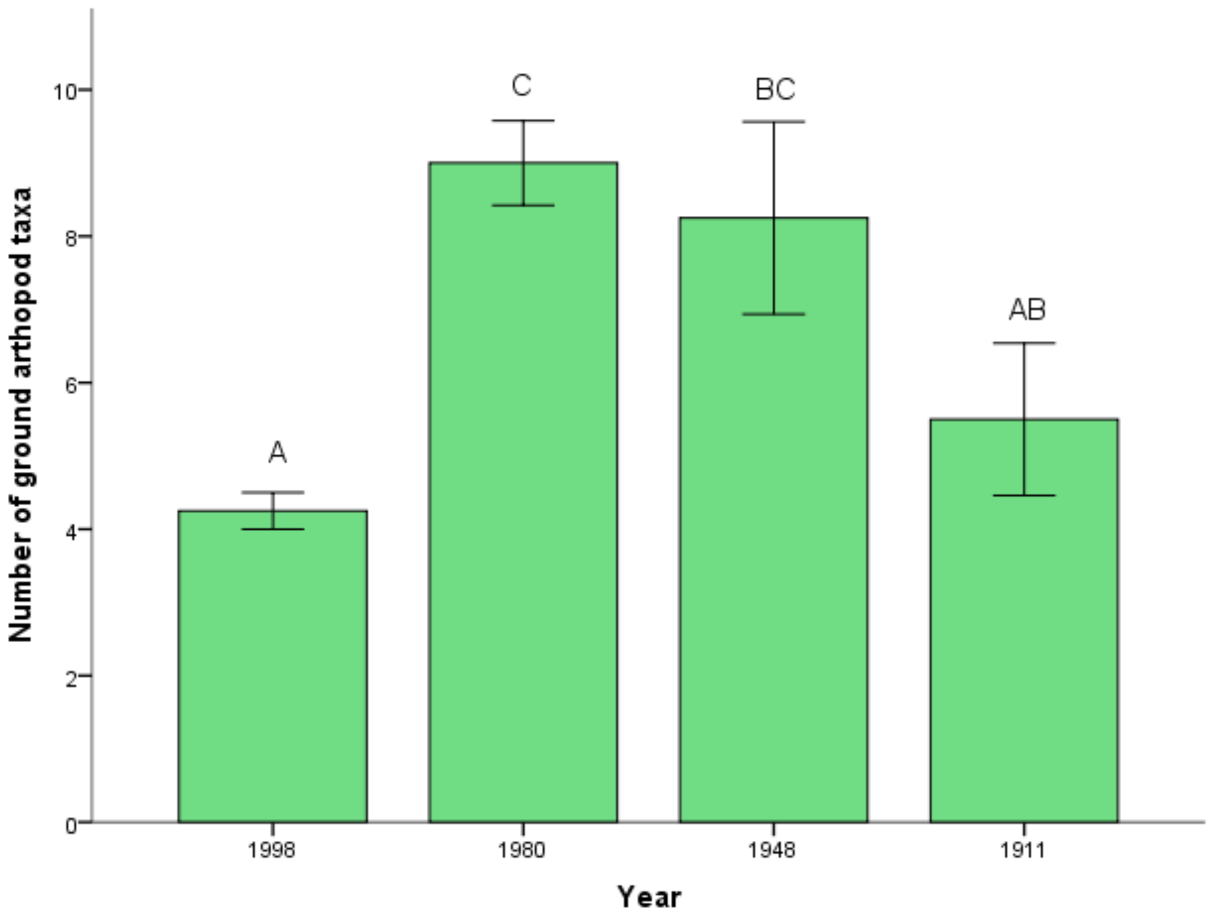

FIG. 6. Mean (±SE) number of arthropod taxa across four different aged stands at the UMBS chronosequence burn plots ($p = 0.008$). Letters represent pairwise differences among years.

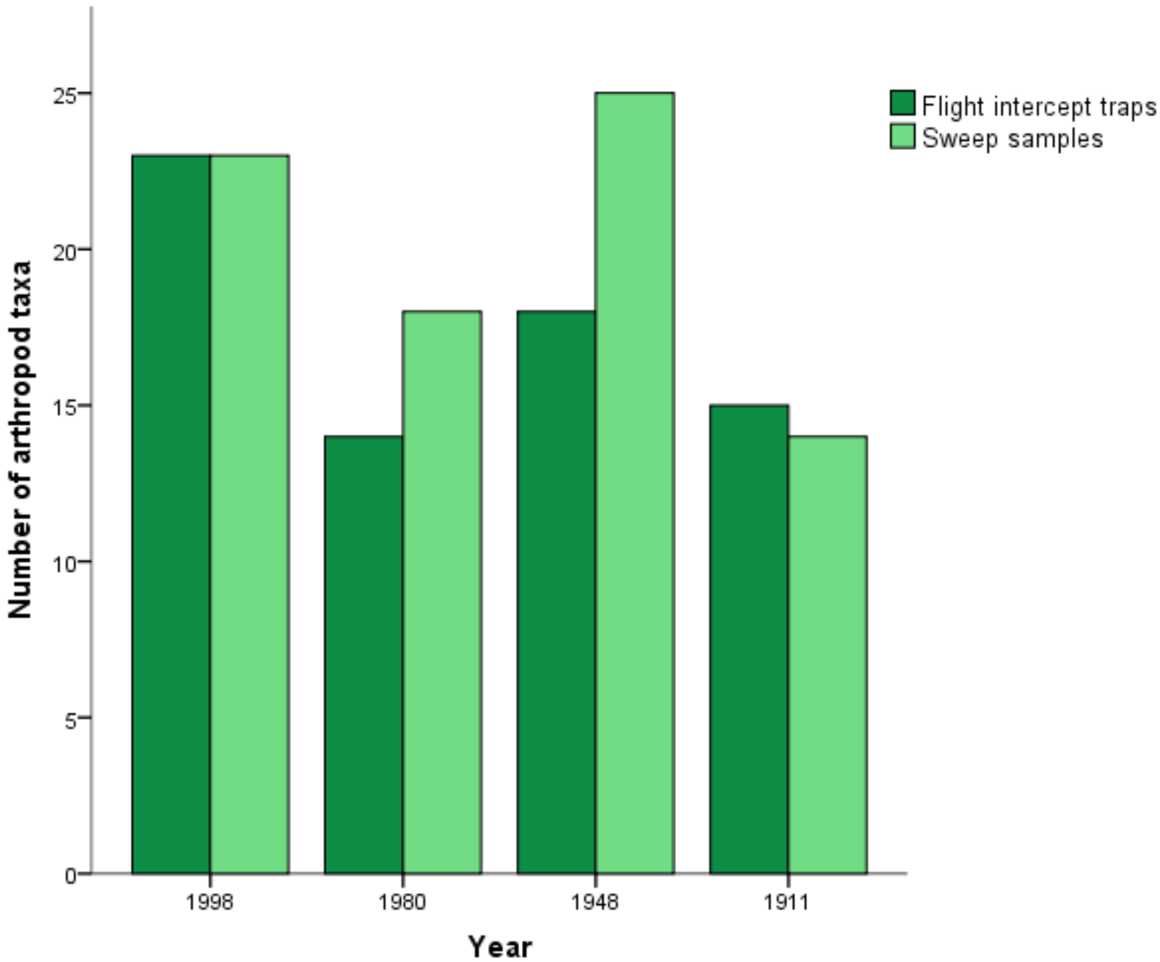

FIG. 7. Number of arthropod taxa in flight interception traps and sweep samples at the UMBS chronosequence burn plots.

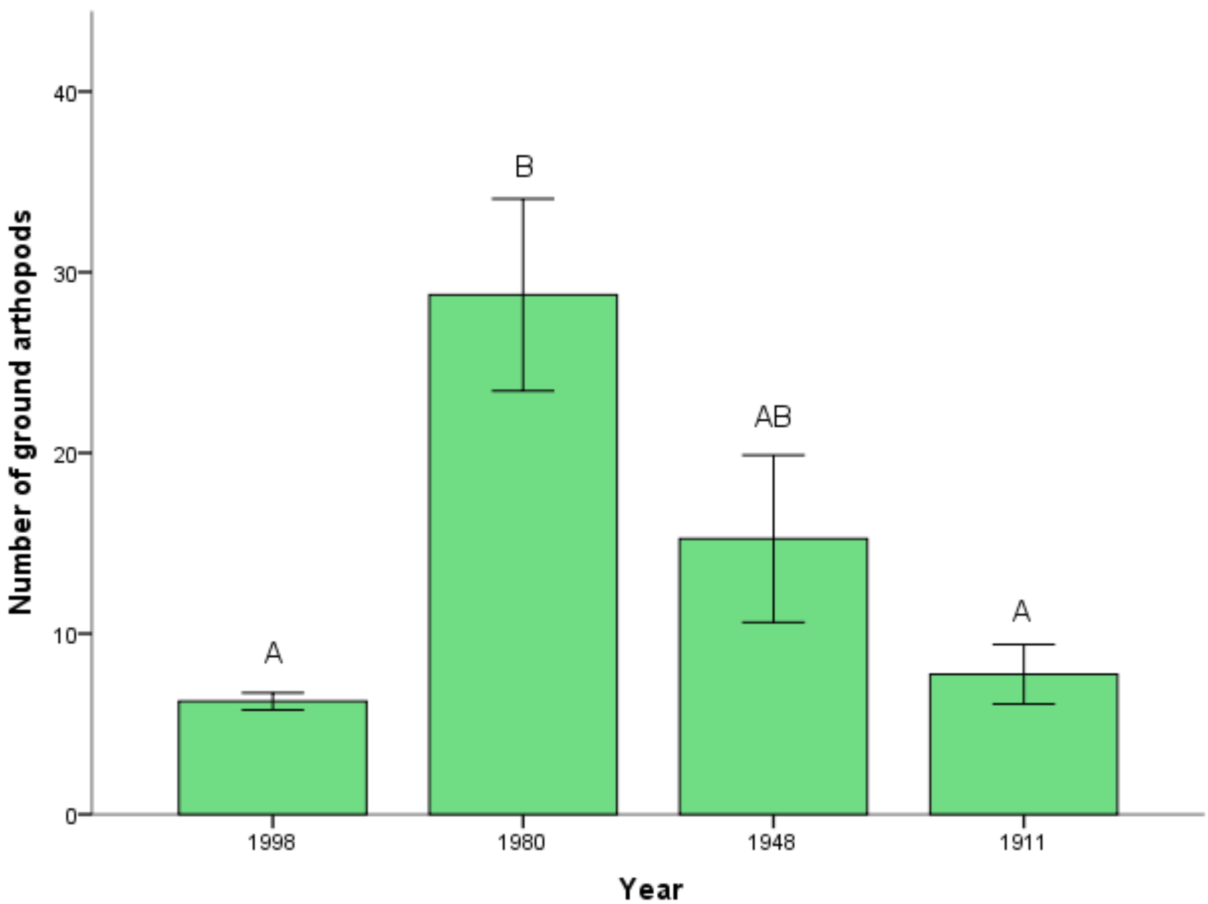

FIG. 8. Mean (±SE) abundance of arthropods in pitfall traps in chronosequence burn plots at the UMBS ($p = 0.003$). Letters represent pairwise differences among years.