Status of *Fraxinus americana* and effect of ash mortality on forest composition on UMBS property

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Course EEB 381: General Ecology
8.17.16
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Abstract

With this study, we aim to determine the status of Fraxinus americana (white ash) on University of Michigan Biological Station property 14 years following the detection of the emerald ash borer in the state. In addition, we investigate how the covertypes of the ecosystems where ash currently exist will change following their death. Building on datasets begun by Douglass Pearsall in the 1980s and 1990s, we resampled permanent plots to determine what species were there and in what quantity. We rated the health of all present ash trees on a numerical scale and took DBH and dripline measurements. From this data we worked with the relative density of overstory and the relative dominance of understory within the canopy gaps to draw our conclusions. Ultimately we found that there has not yet been a significant change in the species richness of the plots that we sampled, nor is there a significant change in the species composition of most of these plots. However, the data we collected do indicate general trends which suggest the potential for several new and interesting research proposals.

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Abstract:

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Introduction:

The University of Michigan Biological Station is located in northern lower Michigan, where the property spans 4,000 hectares in Cheboygan and Emmet counties. The vegetation across the property is highly variable due to the glacial history of the region, which left a patchwork of lakes, moraines and outwash plains behind. (Spurr) The landscape has also been shaped by glacial lakes that once occupied parts of the property – creating wave cut bluffs that have since succeeded into unique forest ecosystem types. Ash trees are a component of several distinct stands within the property, as originally described by Douglass Pearsall in his 1995 dissertation (Pearsall 1995).

The emerald ash borer is non-native invasive species originating in Asia. After introduction to North America, it was first reported to be killing ash trees (*Fraxinus spp.*) around Detroit, MI, in 2002. Since the intital reports, the infestation has spread throughout the lower peninsula of Michigan, as well as into Ohio, Indiana, the Chicago area, Maryland and Pennsylvania (US Forest Service). There are several characteristics that can be used to identify an infested tree before its death: canopy dieback, extensive woodpecker damage, epicormic (trunk) sprouting and D-shaped exit holes (Knight). The borers first attack the tree from its crown where they will eat some of the foliage, these characteristic effects are not directly caused by the adult ash borers but rather their larvae. The larvae feed on the inner bark of the trees, reducing the tree’s ability to transport nutrients and water. This causes the canopy dieback. Woodpecker damage is incurred as they attempt to reach the larvae, and trunk sprouting is the tree’s attempt to continue photosynthesizing by producing leaves below where their xylem and phloem have been damaged by the larvae. Emerald ash borer infestation is nearly always fatal to the host tree, and the progression from healthy state to death can occur within two years (Flower).

White ash are large trees, growing from 18-28 meters tall, typically on rich sites where they are associated with oak, hickory and hop-hornbeam. Lumber from the tree is relatively valuable and is used for furniture and interior trim (Barnes). Ecologically, ash trees are important hosts for 43 native species of arthropods. These species are gall-formers as well as those which feed on its leaves, inner bark, sap, or seeds. Some of these species are completely dependent on ash trees, while others are shared with 1-2 other species of trees (Gandhi 2010). Ash trees also act as a gap-phase and late-successional species which grows larger and lives longer than colonial species. It is also moderately shade tolerant (Barnes). As a result, it is one of few trees species able to persist in mature forest communities, adding to their species richness.

Reports from staff (Syring) at the Biological Station on point toward the presence of emerald ash borer on property, and its presence has been confirmed by the Department of Agriculture and Rural Development in Northern Michigan. We also know where the primary stands of *Fraxinus americana* (white ash – referred to as "ash") trees are on property by using the original surveys done by Pearsall and recently re-catalogued by Raleigh Ricart. However, we do not know how far along the progression of the infestation is on UMBS property or how ubiquitous its presence is across the different ecosystems on property. Additionally, how the cover types of these stands will change with the loss of the ash trees is unknown.

By performing this survey and study, we hope to establish some baseline data on the state of emerald ash borer infestation on UMBS property. From that data, we hope to answer the question: How will the cover types of the forest ecosystems here change as the ash die off? Will ash remain in the understory? Will canopy gaps be filled by existing overstory species, or will other species from the understory succeed the ash? The existing overstory trees will likely only be able to fill the canopy gap of a small ash tree, and in the case of large gaps created by fallen dead ash, there will be an opportunity for understory species to reach the canopy. We hypothesize that the loss of ash trees will lead to a change in the forest cover types on UMBS property and that the species richness across ecosystems where ash are found will fall as well.

Methods:

We surveyed 12 permanent 15x30 meter plots established by Douglas Pearsall distributed widely across UMBS property. At each of these plots, we recorded the diameter at breast height (DBH) of all overstory trees – which were distinguished as being 10cm or more in DBH. Then we located all overstory ash trees within the plot and classified the stage of their infection on a scale from 1 to 4. 1 – No signs of infection; 2 – Some canopy dieback; 3 – significant canopy dieback; 4 – complete mortality. After that, we measured the drip line of the canopy gap left by dead or dying ash trees in two dimensions, creating a rectangular plot. Within the rectangular plot, we measured and recorded the understory – defined as being above breast height but less than 10 cm DBH – within the gap and the percent cover of all woody groundcover species – defined as anything below breast height and having a woody stem. Lastly, we recorded the location of the ash trees within the 15x30 meter plot by measuring their distance from the northeast corner and recording the azimuth at which we measured.

In order to perform our surveys, we used electronic maps with satellite imagery of the region overlaid by the Pearsall Landscape Ecosystem maps and the locations of the permanent plots established by Pearsall. We took these maps with us into the field using an iPad equipped with GPS, as well as a smartphone with GPS and the "Collector" app. We measured tree DBHs using DBH tapes that had centimeter readings which were calibrated to report diameter from the circumference of the tree, as well as using tree calipers. We used Silva Ranger compasses for accurate azimuth readings and five 50 meter ground tapes in order to map out the permanent plots and measure distances from the northeast corner.

To analyze our data, we calculated the species richness of each plot according to Douglas Pearsall's data, our surveys, and our projections for the future. We projected future species richness by calculating the relative dominance of each understory species, and choosing the most dominant species to succeed the dying ash tree overhead. We ran a multiple-samples ANOVA test on the species richness of the plots in the past, at the present and projected for the future. We also ran a chi-square test to compare the species composition of the plots when sampled by Pearsall, when sampled by Ricart (for some plots) and at the present. Species composition was a represented by relative density, which is calculated as the proportion of total stems a particular species represents (#stems of species/#total stems). We chose an alpha level of .05 for all calculations.

Results:

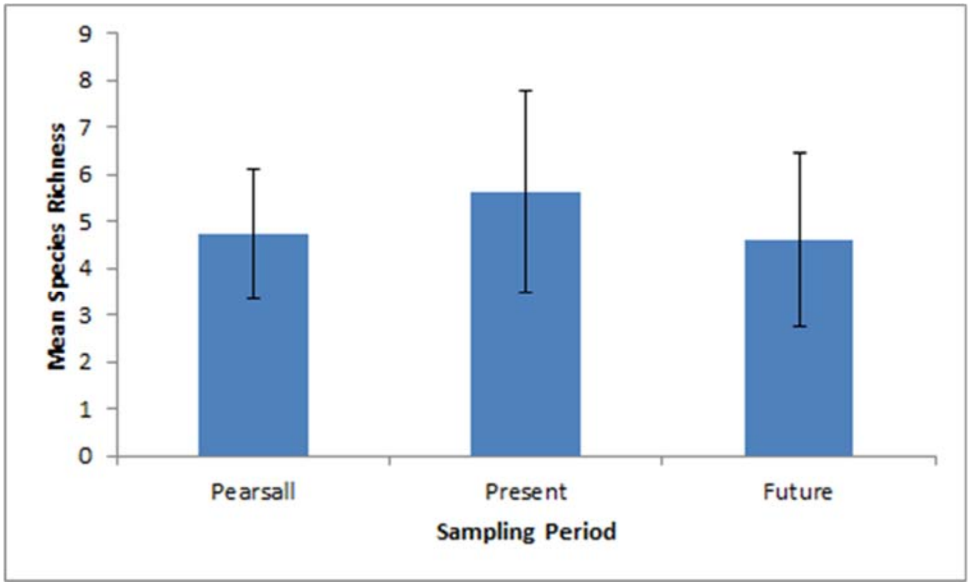


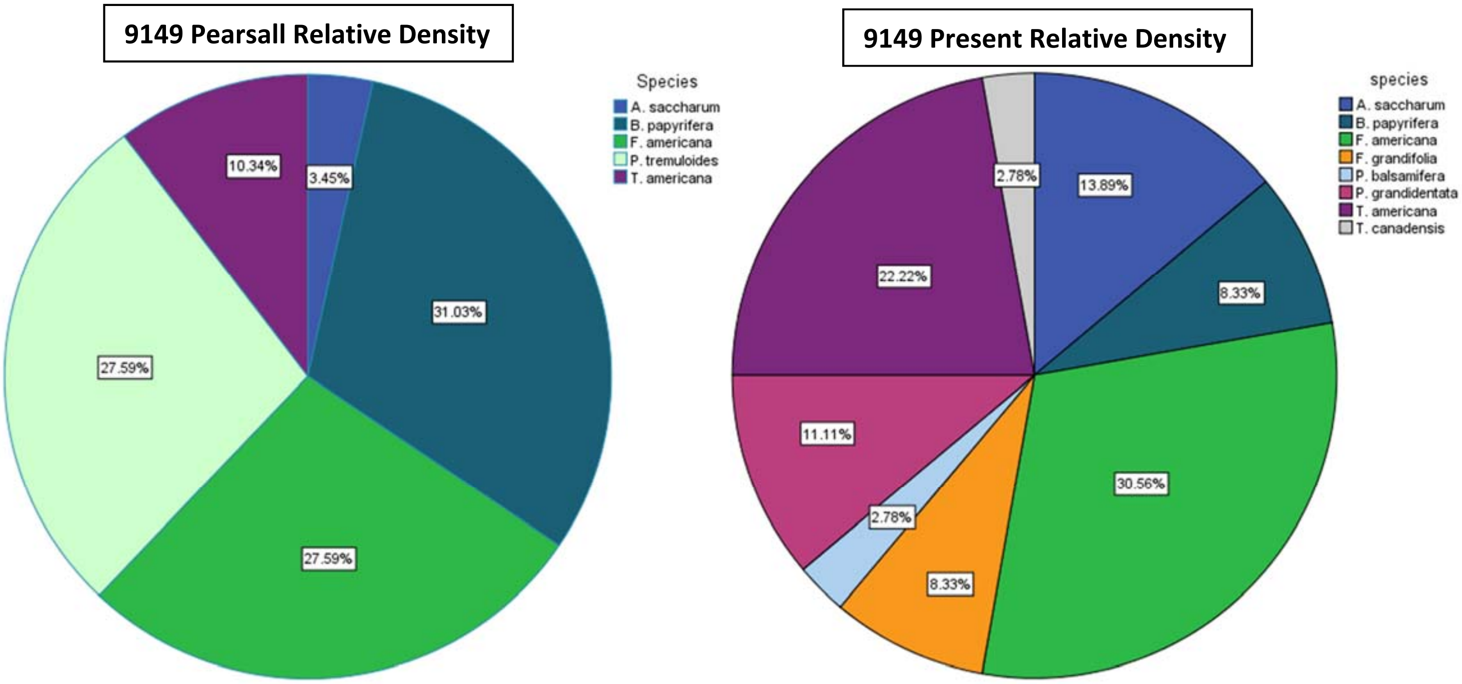
Figure 1: Average species richness across all plots. Bars represent the inner-quartile range generated from standard deviation

	T stat	df	P value
Pearsall vs. Present	-.97206	14	0.347516
Pearsall vs. Future	0.153008	14	0.880576
Present vs. Future	1.00224	14	0.333237

Figure 2: Output of t-tests comparing average species richness in all plots across time periods.

	Pearsall vs. Present			Pearsall vs. Raleigh			Raleigh vs. Present		
	X^2	df	p-value	X^2	df	p-value	X^2	df	p-value
9149	25.7	8	**0.001**	21.9	9	**0.005**	13.8	9	0.13
9329	1.68	2	0.432	0.682	2	0.711	0.741	2	0.69
9271	15.9	7	**0.026**	9.11	6	0.167	11.2	7	0.132

Figure 3: Output of chi-square tests comparing the species composition of plots for which original, resample and present time data were available. Plot 9149 showed a significant difference between original and present time as well as original and resample. Plot 9271 showed a significant difference between original sample and present time



Figures 4 and 5: Overstory species composition of plot 9149 at the time of original sampling and at the present time.

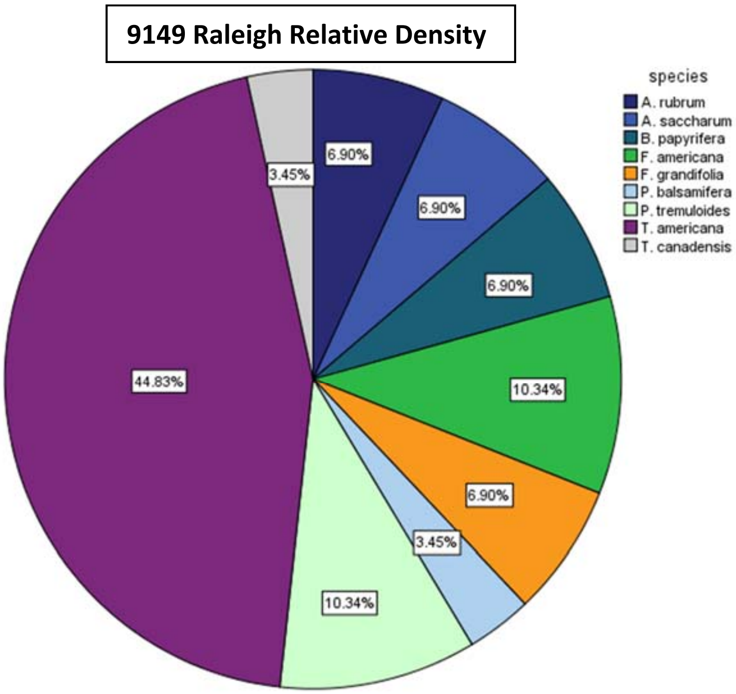
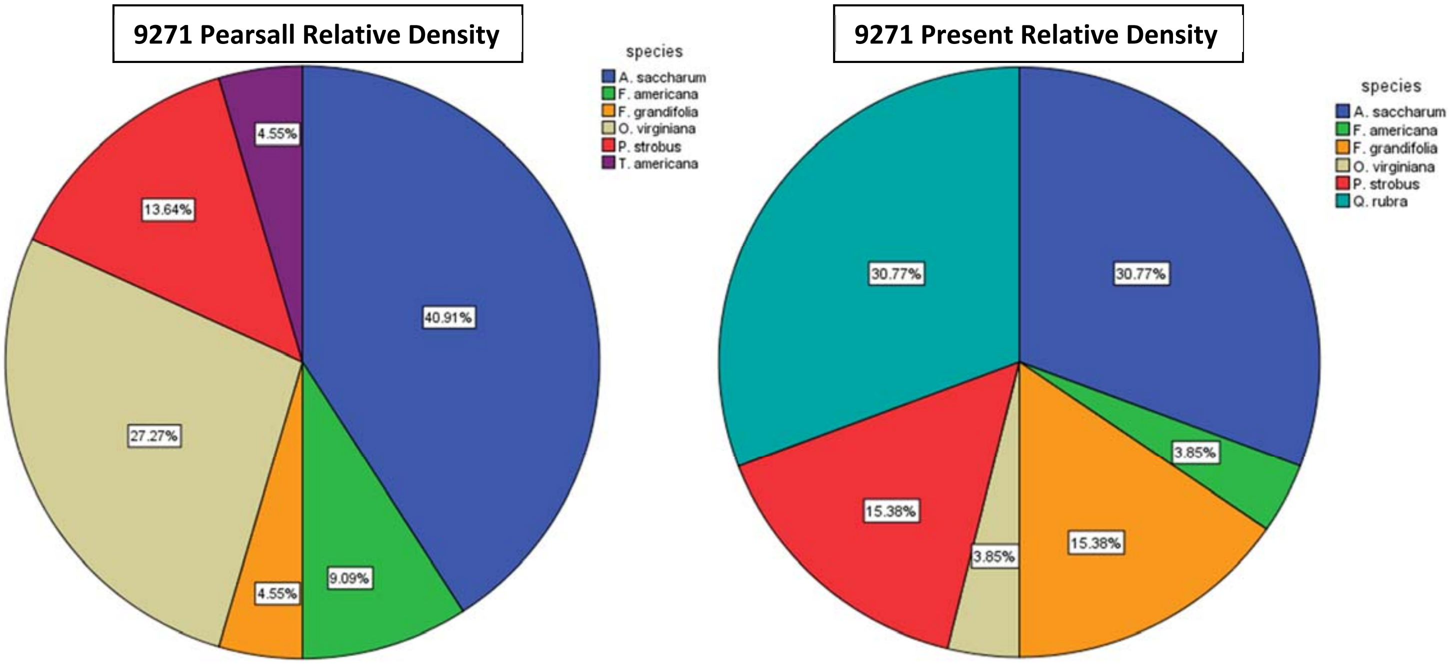


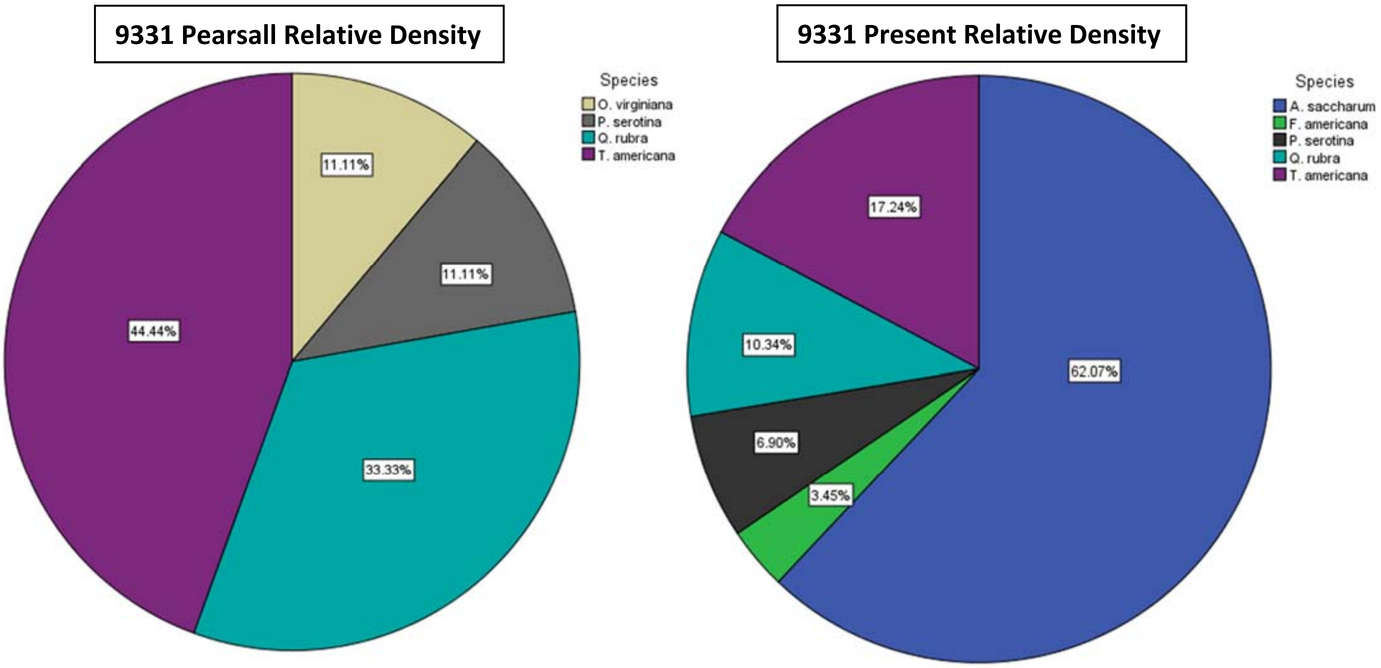
Figure 6: Species composition of plot 9149 at the time of resampling in 2014.



Figures 7 and 8: Species composition of plot 9271 when originally sampled and at the present time.

	Pearsall vs. Present		
Plot	X^2	df	p-value
8813	11.95	7	0.102
9331	14.9	5	**0.011**
9225	2.401	4	0.662
9327	8.31	6	0.216
9401	0.599	3	0.897

Figure 9: Output of chi-square tests comparing the species composition of plots for which only original and present time data were available. Only plot 9331 was significantly different at our confidence level.



Figures 10 and 11: Species composition of plot 9331 at the time of the original sampling and present.

For 29 of the ash sampled, 6.89% were Class 1, 20.69% were Class 2, 17.24% were Class 3, and 55.17% were Class 4.

Discussion:

According to our statistical analysis, our results did not support our hypotheses that we would see a significant change in the forest composition and species richness following the loss of the ash trees from emerald ash borer. However, if we look at the trends in our data, we can see that species richness is lower in all but one plot between Pearsall's sampling and ours. That falling species richness is a result of the dying ash trees, and within those gaps another species of tree is going to dominate. Therefore, the composition is changing as well. The gaps tend be colonized by *Acer saccharum*, but in two cases they were being colonized by *Fagus grandifolia.* The introduction of *F. grandifolia* to the overstory through the gaps left by ash would be interesting because on sites where ash is co-dominant, typically with *Tilia americana* and *A. saccharum*, *F. grandifolia* is not abundant. Despite *F. grandifolia*'s current success, it is also threatened by Beech Bark Disease, which indiscriminately kills beech trees. This means that even if they reach the overstory before being killed by the disease, they eventually will be and are therefore simply delaying colonization of the gaps by either *A. saccharum* or *T. americana*.

Part of our study was the classification of our ash trees, and we certainly confirmed that EAB was present and killing the trees on UMBS property. This raises some interesting questions. Will disturbance accelerate or slow succession toward a mature forest community? These gaps could offer an opportunity for early succession colonial species to find their way back into the forest, or it could move forests more quickly toward a homogenous composition of later successional species such as *A. saccharum*.

How does this affect the net primary production (NPP) and net ecosystem production (NEP) of these forests? As does every species, ash had a particular strategy when competing for sun with other canopy trees. As a result, it contributed to the complexity of canopy layering and efficiency with which solar energy is captured. Will the less complex canopy configuration that may result from the loss of the ash trees cause a decline in the productivity (NPP) of a mature forest that would have otherwise contained ash?

How will the loss of the ash trees impact the arthropods that were associated with the trees? Some of these insects were wholly dependent on the trees. Will the reproductively-immature stump-sprouts that follow the death of an ash be sufficient to sustain these populations? Might there be cascading effects that are unique to Biostation property, outside of those hypothesized by Gandhi and Herms? All of these questions are potential future research topics.

Ultimately, our research serves as a good starting point for future research. We now know the status of ash trees in the stands that are in a variety of ecosystem types across the property, and we have an idea of what will follow in their footsteps. From here we can look more into the effects that these ongoing changes will have on their associated species, the productivity of the forests and the resilience of the biota of these forests.

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