A Comparative Study of the Age Class Structures of *Quercus alba*, *Quercus coccinea*, *Quercus velutina* and *Pinus rigida* as an Indicator of Forest Health within the Long Island Pine Barrens Core Area

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ABSTRACT

Investigation of the age class structure of *Quercus* species and *Pinus rigida* within the Long Island Pine Barrens Core Area is an important aspect of monitoring the health of the Pine Barrens. The age class structures of *Quercus alba*, *Quercus coccinea*, *Quercus velutina*, and *Pinus rigida* are primary indicators of successful reproduction and the possibility of the successional change between community types. By comparing the numbers of seedlings, saplings and mature trees, the success of reproduction for these three *Quercus* species and *Pinus rigida* was analyzed. The numbers of seedlings and saplings were recorded through the use of four two-meter wide belt transects within 16 by 25 meter plots. These plots were located within the Pine Barrens subtargets of Pitch Pine, Pine-Oak, Oak-Pine, Coastal Oak, Scrub Oak and Dwarf Pine forests. This study found the success of reproduction for all the study tree species within the six community types to be varied. *Quercus alba*, *Quercus coccinea* and *Quercus velutina* all displayed a low number of saplings in all community types surveyed, indicating that current reproduction is not very successful. In Coastal Oak and Oak-Pine communities, *Quercus alba* was the most successful in reproduction. The reproduction of *Pinus rigida* was dominant within Pine-Oak, Pitch Pine and Pitch Pine-Scrub Oak Woodland communities. However, the low average number of *Pinus rigida* saplings found could possibly indicate the succession from pine dominated forest to oak dominated forest. There are several factors that may influence these trends in reproduction, including exposure to light, levels of litter and duff, and deer browse. Although the current levels of reproduction for *Quercus* species and *Pinus rigida* are varied and range across the different community types, they are still an important indicator of forest succession from pine to oak dominated forests within the Long Island Pine Barrens Core Area. Forest succession is an important factor in this ten-year longitudinal study of the Long Island Pine Barrens Core Area, as forest succession and species competition are primary indicators of forest health.

INTRODUCTION

The Long Island Pine Barrens, an area comprising 102,500 acres of central and eastern Long Island, is a region of ecological importance [1: 1]. In order to understand the dynamics of the Long Island Pine Barrens, the Foundation for Ecological Research in the Northeast (FERN) developed a monitoring program to collect data to measure indicators of primary ecological attributes of the region. By collecting data on the current conditions of the Pine Barrens, the monitoring program will be able to provide a baseline of forest health in order to determine the actions of further conservation efforts. When the data is collected again in ten years, the monitoring program will also serve to detect and document the degree and direction of change in forest health, and to identify the priorities of research within the Long Island Pine Barrens [2: 3].

The objective of this research is to study the age class structure of *Quercus alba*, *Quercus coccinea*, *Quercus velutina* and *Pinus rigida* so that they may be used as primary indicators of the successful reproduction patterns and the possibility of successional change from a pine to an oak dominated forest. The pattern of succession from a pine dominated forest to an oak dominated forest is from Pitch Pine forest, to Scrub-Oak Forest, to Pine-Oak forest, to Oak-Pine forest, and finally to Coastal Oak forest [3: 8]. Another objective of this research was to use the rates of reproduction of *Quercus alba*, *Quercus coccinea* and *Quercus velutina* to foresee the possible dominance of one particular *Quercus* species in the stages of forest succession. These findings will help to determine both the current and future ecological integrity of the Long Island Pine Barrens Core Area.

A map of the Central Pine Barrens. Courtesy of http://www.ph.state.ny.us.

METHODS

The data for this research was collected by following the Monitoring Protocols for Central Pine Barrens Field Plots. Data from 90 randomly generated plots located within six different community types was collected. The numbers of seedlings, saplings and mature trees were recorded within various randomly generated plots within the core area of the Central Pine Barrens of Long Island. These plots within the different subtargets of the Central Pine Barrens target were generated using Geographic Information System (GIS) software. The plots had dimensions of 16 by 25 meters, and were located at least 50 meters from any human disturbances (roads, houses, etc) and at least 25 meters from any ecological boundaries or differing community types. The subtargets studied were the communities of Pitch Pine forest, Pine-Oak forest, Oak-Pine forest, Coastal Oak forest, Scrub Oak forest, and Dwarf Pine Plains. To estimate the number of seedlings and saplings within each of the plots, four 2 by 25 meter transects were sampled. The entire area that was sampled for seedlings and saplings of different pine and hardwood species was 8 by 25 meters, or half of the surveyed plot.

To measure the number of mature trees within each of the plots, hardwood and pine species that had a dbh (diameter at breast height) greater than 2.5 cm and less than or equal to 10 cm, and those that had a dbh greater than 10 cm were recorded. The diameter of the trees was measured at 1.37 meters from the ground using either calipers or a dbh tape. Trees that fell in these categories were measured by dbh to the nearest millimeter and then tallied. As was the case with seedlings and saplings, if tree split below the diameter at breast height into two or more stems, the tree was still counted as being singular.

The numbers of seedlings, saplings and trees collected throughout the surveying of these plots were compiled in a Microsoft Access database. After the completion of 90 plots, the averages of the numbers of seedlings, saplings and mature trees were calculated. These averages were then used to generate graphs displaying the age class structures of *Quercus* species and *P. rigida* and relationships between *Quercus* species reproduction and *P. rigida* reproduction in the stages of forest succession.

RESULTS

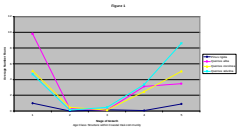

Table 1: Coastal Oak Community

	A	B	C	D	E
Pinus rigida	1	0	0.16	0.05	0.89
Quercus alba	9.8	0.32	0.11	3.11	3.47
Quercus coccinea	5.1	0.47	0.11	2.47	5.05
Quercus velutina	4.68	0.11	0.47	3.36	8.6
Average of all species	5.3	0.23	0.21	2.25	4.50
Standard deviation	3.6	0.21	0.17	1.51	3.23

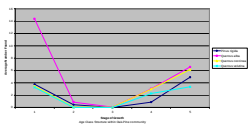

Table 2: Oak-Pine Community

	A	B	C	D	E
Pinus rigida	3.74	0.45	0	0.87	4.9
Quercus alba	14.35	0.87	0.06	3	6.55
Quercus coccinea	3.48	0.06	0.06	2.97	6.16
Quercus velutina	3.26	0	0	2.26	3.32
Average of all species	6.21	0.35	0.03	2.28	5.23
Standard deviation	5.43	0.40	0.03	1.0	1.46

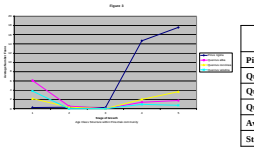

Table 3: Pine-Oak Community

	A	B	C	D	E
Pinus rigida	0.25	0.33	0.25	14.67	17.58
Quercus alba	6.08	0.58	0	1.42	1.75
Quercus coccinea	2.17	0.33	0	2	3.67
Quercus velutina	3.83	0	0	0.92	0.72
Average of all species	3.08	0.31	0.06	4.75	5.93
Standard deviation	2.48	0.24	0.13	6.63	7.86

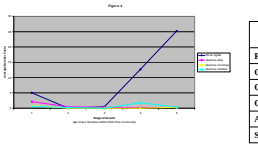

Table 4: Pitch Pine community

	A	B	C	D	E
Pinus rigida	5	0	0.44	12.67	25.17
Quercus alba	2.2	1.56	0	1.78	0.06
Quercus coccinea	0.67	0.67	0.06	1.67	1.28
Quercus velutina	0.61	0.22	0	1.78	0.33
Average of all species	2.12	0.6125	0.125	4.475	6.71
Standard deviation	2.06	0.69	0.21	5.46	12.32

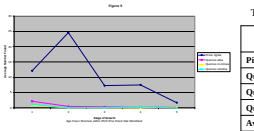

Table 5: Pitch Pine-Scrub Oak Woodland Community

	A	B	C	D	E
Pinus rigida	5	0	0.44	12.67	25.17
Quercus alba	2.2	1.56	0	1.78	0.06
Quercus coccinea	0.67	0.67	0.06	1.67	1.28
Quercus velutina	0.61	0.22	0	1.78	0.33
Average of all species	2.12	0.6125	0.125	4.475	6.71
Standard deviation	2.06	0.69	0.21	5.46	12.32

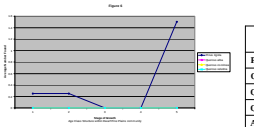

Table 6: Dwarf Pine Plains Community

	A	B	C	D	E
Pinus rigida	0.25	0.25	0	0	1.5
Quercus alba	0	0	0	0	0
Quercus coccinea	0	0	0	0	0
Quercus velutina	0	0	0	0	0
Average of all species	0.06	0.06	0	0	0.38
Standard deviation	0.13	0.13	0	0	0

In each of the figures and tables used for this research, the stages of growth are shown for each species across the six different community types. By viewing the transformation of *P. rigida* and the *Quercus* species from seedlings to saplings to mature trees, the age class structure of each species can be studied. For successful reproduction, each of the species studied will have a moderate to high number of seedlings, followed by a lower number of saplings (both between 0.5m and 2m and >2m with a dbh <2.5 cm). In healthy reproduction, the number of trees (both trees with a dbh <10cm and trees with a dbh >10cm) will increase to an average number higher than the average number of seedlings found.

For all figures and tables, the different stages of growth are represented by numbers. Seedlings are represented by A; saplings between 0.5m and 2m with B; saplings >2m and having a dbh less than 2.5cm with C; trees having a dbh less than 10cm with D; and trees with a dbh >10cm with E. The average numbers of and standard deviations for seedlings, saplings and mature trees found within the six different community types were found using the Microsoft Excel program.

Pictured above is a Quercus alba seedling. At center is a Quercus velutina leaf. At right is a Quercus coccinea leaf. Photos courtesy of www.pinebarrens.org

DISCUSSION AND CONCLUSION

The age class structures of *Quercus alba*, *Q. coccinea*, *Q. velutina* and *Pinus rigida* normally show a high number of seedlings, followed by a decrease in numbers as seedlings mature into saplings [2:33]. In order for *P. rigida* or any of the *Quercus* species to exemplify healthy patterns of reproduction, the graph representing their age class structure should display an increased average number from saplings to mature trees, following the slight decrease in average number from seedling to sapling. A high number of mature trees indicate successful reproduction patterns and overall forest health. Therefore, graphs representing the age class structure of the study species are supposed to resemble a "reverse J". Although the average number of species found per plot is supposed to decline from seedlings to saplings, the scarcity of seedlings or saplings is an indicator of the possibility of failure of tree reproduction. If the numbers of seedlings and/or saplings are very low, reproduction can be seen to be struggling [2: 33]. From this study, the range of success of reproduction between species and across the six different community types can be seen.

In studying the age class structures of the study species, it is important to look at these trends both in terms of individual species success and overall forest succession. Within the Coastal Oak and Oak-Pine communities, *Q. alba* appeared to have the most successful reproductive patterns. Factors which may influence the success of *Q. alba* over *Q. coccinea* and *Q. velutina* include include exposure to light, litter and duff depth, and the extent of deer browse [2: 34]. In order for *Quercus* species to grow, they need an adequate amount of light and fairly deep levels of litter and duff [4: 15]. If these conditions are not met, and there is deer overbrowse due to the increasing deer population in the area, the reproduction of *Q. alba*, *Q. coccinea* and *Q. velutina* will be unsuccessful [2: 34].

The possibility of successional change from pine dominated forest to oak dominated forest exhibited by the data from Pitch Pine and Pitch Pine-Scrub Oak Woodland communities is another aspect of reproductive patterns that are an important aspect of monitoring the Long Island Pine Barrens. Although there is some indication that these community types are undergoing succession, it is also likely that they are uneven staged forests. The reason why there are few saplings may not just be the fault of inadequate exposure to light, unsuitable levels of litter and duff, or extent of deer browse, but also may be due to different periods of growth exhibited within a surveyed community [4:14]. The number of saplings greater than two meters may be low because seedlings and saplings that are less than two meters have not had enough time to grow to further stages of maturity yet. The fact that the Pine Barrens is an uneven aged forest may also explain why there are higher average numbers of trees found within the surveyed plots while the average number of saplings was low.

Additionally, forest succession is difficult to monitor because there may not be a climax community toward which the Pine Barrens will be evolving. Rather, what the Long Island Pine Barrens appears to show us is that it is a community containing many different periods of succession. Instead of moving toward a climax community, reproductive patterns and forest succession reveal that there is an ongoing struggle between different species for light, food and nutrients contained in litter and duff. This struggle allows certain species to reproductively succeed, and others to fail in the face of varying environmental conditions [5: 70] Thus, the overall course of succession can not necessarily be predicted. By studying the individual reproductive patterns of *Quercus alba*, *Quercus coccinea*, *Quercus velutina* and *Pinus rigida* across the six different community types, the successes and failures of each species can be better understood. Future monitoring of the Long Island Pine Barrens will be needed in order to follow and preserve the natural progression of each of these species and their age class structures.

REFERENCES

[1] "The Long Island Pine Barrens: A Curriculum and Resource Guide". Pine Barrens Society. 6 July 2005. http://www.pinebarrens.org.

[2] Batcher, Michael S. "Monitoring Protocols for Central Pine Barrens Field Plots, Version 1.01". Prepared for the Upton Ecological Reserve, Brookhaven National Lab. 12 June 2005.

[3] Buckholz, Kenneth and Ralph E. Good. "Density, age structure, biomass and net annual aboveground productivity of dwarfed Pinus rigida Mill. From the New Jersey Pine Barrens Plains." Bulletin of the Torrey Botanical Club 109 (1982) pp24-34.

[4] Jordan, Marilyn J., William A. Patterson, III and Andrew G. Windisch. "Conceptual Ecological Models for the Long Island Pine Barrens: Implications for Managing Rare Plant Communities". Forest Ecology and Management 158 (2003), pp151-168.

[5] Miller, Tyler J. Sustaining the Earth. Pacific Grove, CA: Brooks Cole, 2005. 70.

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