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REGROWTH RATES AND SUCCESSIONAL PATTERNS OF PREVIOUSLY "CLEAR CUT" BAHAMIAN PINE YARDS, ANDROS ISLAND, BAHAMAS

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ABSTRACT

From the 1950's to 70's Owens of Illinois Lumber Co. "clear cut" much of the Bahamian Pine (*Pinus caribaea* var. *bahamensis*) on north and central Andros Island, Bahamas. The lumber was mostly used as pulp for cardboard containers. The permit mandated that a pre-selected 5% of the pines be left to "naturally" reseed the pine yards. This study is focusing on the successional patterns of the pine regrowth after intervals of 30, 40, 50 and nearly 60 years compared to areas that remain unlogged. The point quarter method was used in sites near Forfar Field Station (Big Pond Settlement), Red Bays, San Andros Airport and along the Queen's Highway north of Stafford Creek. Tree core samples were also taken to determine growth rates and age averages for each stand sampled. Data has been collected over a four-year period (1999 to present) and will be continued. The study will help to assess the success of the regrowth strategy in order to determine potential for sustainable logging operations in the future.

INTRODUCTION

Forests cover about fifteen percent of the total land area of the Bahamas, mainly located on four islands of the North-western Bahamas: Abaco, Andros, Grand Bahama, and New Providence (FAO, 2000). These forests of the Bahamas have been classified into three distinct types, namely pine forests, coppice forests, and mangrove forests. Of these forest types, the pine forests are considered the most productive and commercially viable resource, comprising an estimated 213,861 ha on the northern Pine Islands of Abaco, Andros, Grand Bahama, and New Providence (Russell, 2000). These forests are largely a monoculture of self-regenerating *Pinus caribaea* var. *bahamensis*.

The pinelands of Abaco and Andros islands have been cut numerous times for timber, but their main harvests were for pulpwood. Caribbean pine possesses a naturally heavy and dense wood, thus it is commercially a valuable wood due to its termite resistance. Pine forest utilization commenced in 1906, while under British rule, when the first license was issued to exploit the resource. During the1950's-1970's the Owens of Illinois Lumber Company intensively logged the pine forests on Andros Island. Similar harvests took place on the island Abaco, where all trees over 10cm diameter at breast height (dbh) were removed for pulpwood by the year 1970 (Lee, 1996). Owens-Illinois' permit mandated that a pre-selected five percent of the pines (based on vitality) be left to naturally reseed the pineyards. This was intended to create a faster and more natural successional pattern giving the pine trees a comparative advantage over other faster populating species.

As a result of these harvests, the forests on Andros are now composed almost entirely of 30-year regrowth pines, approximately 9-12m in height, with strong regeneration of younger age classes of pines throughout (Lee, 1996). Additionally, the individual trees that were left for reseeding during the time of Owens-Illinois' operations remain scattered irregularly throughout the pine yards. These trees have only a slightly larger dbh than the younger forest, and their crowns are only about 3m above those that are secondary growth. This raises the question: at what rates are the pine forests recovering, and what successional patterns are they undergoing? A comparison between the remaining virgin pine forests and the harvested pine yards would establish an understanding of the regrowth process occurring in the pine forests on the island of Andros. An understanding of regrowth periods and patterns in the Androsian pine forests would, in turn, provide highly beneficial assistance and information in determining the feasibility of future commercial logging environmentally sustainable resource utilization on Andros Island.

The objective of this ongoing study is to investigate regrowth rates of *Pinus caribaea* in the pineyards following the timber harvest by the Owens of Illinois Lumber Company, and to determine if any secondary successional patterns have been established. It will test the following hypotheses: (1) the pre-selected trees have adequately reseeded the pine yards, and (2) natural succession patterns have occurred, establishing Bahamian Pines as the dominant species.

METHODS

Prior to any fieldwork, previously acquired data was reviewed to provide appropriate direction. Previous sampling had been completed in stands near the communities of South Blanket Sound, and Red Bays, therefore sampling was conducted at different sites. Forest sampling was performed using a plot-less method known as the point-quarter method (Smith, 1996), to determine the density of the pines within the forests.

Point quarter sampling consists of the location of a series of random points within the stand to be sampled, or the selection of random points along a line transect passing through the stand. These points become focus points. At each point, the working area is divided into four quarters or quadrants by visualizing a grid line, predetermined by compass bearing, and a line crossing it at right angles, both passing through the point. The closest tree in each quarter to the focus point is selected. Distance from the point to the tree is recorded, along with the dbh and species of the tree. Species and distance is similarly acquired for the nearest sapling in each quadrant. Specific size requirements are used to distinguish appropriate tree and sapling qualifications. In order to be a "tree" the plant must have a dbh >8cm. In order to be a "sapling" the plant must have a dbh<8cm and a minimum height of 3m. Sampling was conducted using dbh metric tapes, a laser range finder, and GPS units to track and record location of points to ensure reliability and reproducibility.

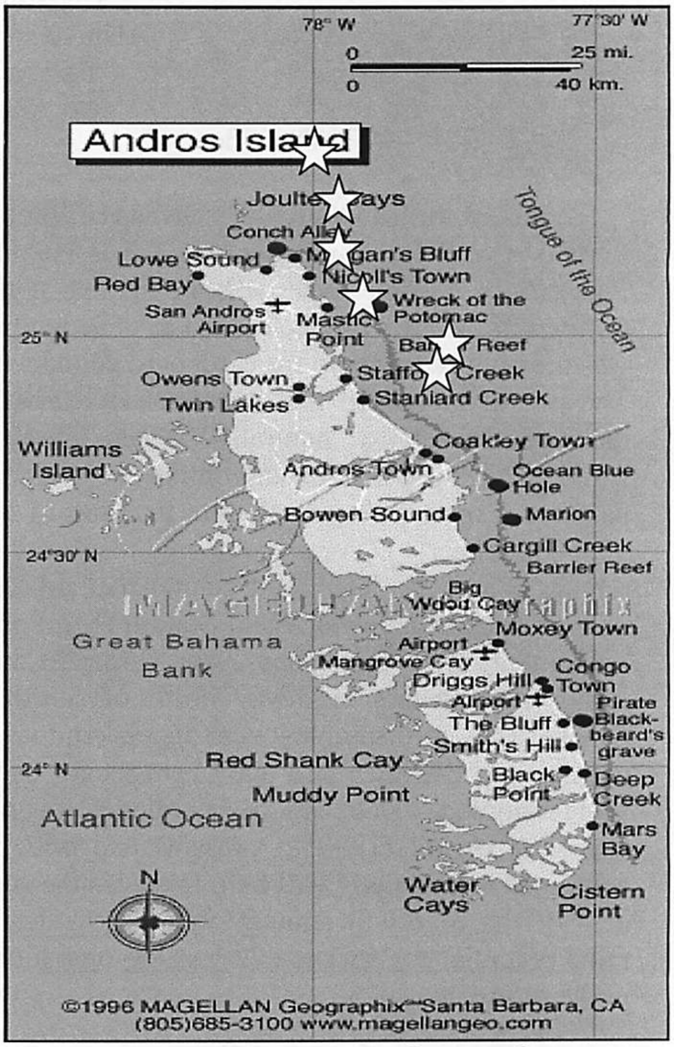

Figure 1. Site locations for sampling.

A field base was established at Forfar Field Station, South Blanket Sound. Six different stands were sampled. Sampled stands were located at the following locations: Big Pond Settlement (located adjacent to Forfar Field Station), north of San Andros Airport, Charlie's Blue Hole, near London Ridge, north of Rainbow Blue Hole, and south of Morgan's Bluff. Samples consisted of sets of 10 or 20 focus points. Refer to Figure 1 to see site locations. Big Pond Settlement was the only stand sampled that is virgin forest. Location of another uncut stand was attempted in South Central Andros near Behring

Point and Cargo Creek, but the pineyards were inaccessible by any means of land transportation available, and any yards that were sampled were predominantly regrowth.

All dbh and distance data were recorded and entered into the database. The distances from each stand, the area containing the focus point, were added together. The summation of these numbers was then divided by the total number of points per stand, squared, and divided by 10000m to acquire the density of each stand in trees per hectare. The dbh measurements, taken in centimeters, were converted into basal area measurements using a series of mathematical calculations. These area measurements are then added together, divided by the number of points per stand, and multiplied by the locality's previously determined density. This respectively determines the basal area per stand in m^2/ha.

Additionally, core samples were taken from several strands using an increment borer to determine relative ages of trees and provide another variable to compare between uncut and cut stands, beyond density and basal area. Core samples were taken in the following stands: Big Bond Settlement, north of San Andros Airport, and Morgan's Bluff. Core samples were obtained and preserved in straws while in the field. Upon returning to the lab, the samples were examined under a dissecting microscope to count incremental growth rings.

Core samples were obtained from the San Andros Airport, Morgan's Bluff, and Big Pond Stands. At current date the core samples are not revealing discernable growth rings to indicate approximate ages of tree stands. This will be elaborated on further in the discussion.

RESULTS

The following table shows totals for each stand.

TREES STAND	TREES/ha	BA/ha
BIG POND	565.2127	13.59143
SAN ANDROS AIR PORT	736.7109	14.36814
CHARLIE'S BLUE HOLE	1735.677	21.1206
LONDON RIDGE	691.6541	14.73086
RAINBOW BLUE HOLE	850.4818	14.22794
MORGAN'S BLUFF	901.8352	16.83726

SAPLINGS STAND	SAPLINGS/ha
BIG POND	1640.589913
SAN ANDROS AIR PORT	258.3316865
CHARLIE'S BLUE HOLE	388.2769406
LONDON RIDGE	183.0402452
RAINBOW BLUE HOLE	675.3164069
MORGAN'S BLUFF	588.4309766

DISCUSSION

Simple visual inspection indicates that the pine yards have successfully undergone secondary succession, and are once again the dominant tree in the forests. The data acquired seems to support this initial observation. The data further supports that the previously cut pineyards have now become more densely populated by the species *Pinus caribaea* than the virgin yards. The Big Pond stand, which has been sampled twice over the past two years, has exhibited considerably lower *P. caribaea* densities than the other sampled locales that have been logged within the last 50 years. 2003 sampling numbers for Big Pond indicate a density of app. 565 trees/ha. 2002 number for the same locale indicate app. densities of 557 and 670 trees/ha. Each figure indicates lower relative densities of *P. caribaea* than any other sampled stand to date in the study.

This can somewhat be explained when observing the relatively high sapling density (app. 1640/ha) in Big Pond, compared to densities ranging from 258-675 from the other locales. The virgin forest has developed a much denser and diverse understory layer. Typically in the cut yards the majority of sapling species recorded included *P. caribaea, Metopium toxiferum* (poisonwood), *Coccothrinax argentata* (Silver Thatch Palm), *Acacia pinetorum* and *Acacia farnesiana* (Pine Acacia and Sweet Acacia), Bahamian Strongback, Five-Fingers, and *Coccoloba diversifolia* (Pigeon Plum). The virgin yard was the most uniformly diverse stand sampled. Many of the cut yards indicated very uniform variety of species, often found in clusters. This could indicate some differences between the earlier successional patterns taking place in the cut yards in comparison with a more mature, untouched, virgin forest.

Other factors, however, must also be considered. Fire cycles play an incredibly important role in the natural ecology and successional patterns found within the pine yards of Andros. Knowledge of the timing and frequency of these fires would be helpful in determining whether the sapling densities and distributions were a result of an uninterrupted regrowth period after logging activity, or a result of episodic fire events. Sampling in stands before and after such natural fire events would be very beneficial to better understanding some of the successional patterns. Furthermore, prescribed burns could also allow to better understand the fire-induced successional patterns that might be taking place.

From data acquired thus far in the study, however, the succession of the pineyards seems to be approaching the later stages. *P. caribaea* is the dominant species, and seems to be thriving. Sampling numbers in the cut yards indicate that the pineyards have successfully regenerated themselves in a period of less than 50 years. Dbh numbers are on the average higher in the virgin stand and the older trees, however, when taking the relative density numbers into account from each stand, there is not a significant difference in total volume of wood available in the forests. This is not to say that the younger trees are near the maturity or wood quality that the older trees are, however, in terms of yield, there seems to be similar volumes.

Differences between the cut and uncut stands sampled mainly exist in understory growth. This could be the result of a number of factors, including fire, canopy shielding, hurricane-force winds, etc. Many of the sampled stands exhibited char markings along the lower 5 feet of the trunks of the trees. Further investigation is needed upon the effects of fire in order to determine the successional patterns that could occur in the event of another logging operation.

Further investigation is also needed into core sample analysis and acquirement. Relatively few core samples were obtained. The denseness of the wood, and age of the borer used, led to extreme difficulty in obtaining whole core samples. The samples were difficult to examine as they were often broken into pieces and scratched from the borehead. Those that were obtained intact posed further difficulty in analysis.

Many of the cores were resin laden and exhibited scratches from the increment borer. There are some samples in which distinct rings are visible and countable, however others are not. Several methods for improving the condition for visual inspection are suggested. Application of a solvent for natural resins, such as methanol or acetone, to the samples may cause the resin to settle and migrate downward, eliminating some of difficulty posed by resin covering discernable tree rings. Phloroglucinol may also be applied to the samples, staining the lignin and leading to a more pronounced and discernable ring pattern. These procedures are suggested to aid growth ring counting. This, however, is not the largest difficulty that has arisen concerning the obtained core samples.

The foremost of the difficulties is that the time increment represented by a visible growth ring is unknown. All stands sampled are located at latitudes below 30°. Annual growth rings do not appear in trees located below 30° latitude. For annual rings to form, trees must "shut down" growth at some point to form a distinct ring boundary. This occurs in the dormant season, usually in the fall and winter. In the tropics (within 30°N and 30°S latitude) the seasons are not as distinct, and trees can grow year-round. This was an oversight when dendrochronology and annual ring counts were originally suggested and then attempted to determine approximate tree ages.

Tropical trees, however, do still produce incremental growth rings. The rings however, are formed as increments caused by rainy and dry seasons based on precipitation cycles and events. Growth rates, and consequently growth rings can also show dependencies on variation in solar input, relative humidity and other climatic variables (Enquist & Leffler, 2001). Tropical trees may have more than one growth ring per year, or they may have one growth ring indicating a number of years depending upon the rainy and dry seasons. Further investigation into island rainfall cycles, similar tropical dry forest habitats, similar tropical dry forest species, and similar *Pinus* species is currently taking place, and is suggested to continue in order to establish a time increment coinciding with an observable growth ring.

With these suggestions and further investigation the core samples will hopefully provide information to determine approximate ages of the trees. If ages are obtained, then it is suggested that further core sampling take place in order to reproduce similar core ages to validate the data thus far obtained.

While researching *Pinus* species it was also found that pine trees make another record of how well they grow each year, beyond the growth rings. Pines put out only one group or circle of buds for new branches each year. It is possible to count the number of circles of branches to find out approximately how old the tree is. Further investigation of this technique's relative use on trees in tropical dry pine forests is needed to see if this may be a productive technique. This method would also pose logistical difficulties that would have to be overcome.

CONCLUSIONS

The logged pine yards seem to have successfully repopulated; they have even established higher densities of *P. caribaea.* The future of this study largely lies on the analysis and acquirement of core samples to better establish accurate approximations of tree ages. An accurate time approximation could then be made to determine the period of time that is necessary for natural successional patterns and repopulation to occur.

An additional aspect of this study is also advised. Investigating the fire ecology of the forests would largely help understand and explain the undergrowth and sapling successional patterns. Additional fieldwork is planned on Andros and in virgin pineyards on Abaco in January 2004.

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