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R. Dicce

*West Chester University of Pennsylvania*

D. Drake

*West Chester University of Pennsylvania*

D. Mackey

*West Chester University of Pennsylvania*

P. Avery

*West Chester University of Pennsylvania*

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**FOREST ANALYSIS OF THE GORDON NATURAL AREA FOCUSING ON CARBON STOCK, FOREST STRUCTURE, AND FOREST COMPOSITION**

R. Dicce, D. Drake, D. Mackey, and P. Avery  
Department of Geography and Planning  
West Chester University of Pennsylvania  
700 South High Street  
West Chester, PA 19383

## **ABSTRACT**

*This project explores the carbon stock of the Gordon Natural Area (GNA) located on West Chester University's campus. In order estimate the carbon stock, fifteen 20-meter circular plots were surveyed. The diameter-at-breast-height (DBH) and species type were catalogued. This was used to determine that the mean carbon stock per hectare of the GNA is 240.468 t C/ha. A statistical analysis showed that the plots were all remarkably similar and this allowed the data to be augmented over the total northern area of the GNA for an approximate carbon stock of 5,499.502 t C. In addition, an analysis of the species composition and structure revealed that the GNA is a relatively young forest with an overwhelming majority of the trees being American Beech.*

**Keywords:** *carbon stock, forest structure, forest composition*

## **INTRODUCTION AND LITERATURE REVIEW**

In 1971, the West Chester Board of Trustees set aside a patch of land on south campus in order to preserve a climax forest (Overlease, 2006). Since then, the Gordon Natural Area (GNA) has served as a natural laboratory of ecological and geographical study (Beneski, 2011).

Forests are important ecological features that are in danger of being depleted worldwide. Today forests only cover approximately 28% of all land surfaces but account for almost 80% of all carbon on Earth (Hamdan, 2011). In 2011, West Chester University made a commitment to becoming a carbon neutral campus (Weisenstein, 2011). Carbon is stored in the biomass, above and below ground as well as the soil of the forest (Tolunay, 2011; Birdsey & Heath, 1995). Therefore, a key component of achieving the goal of carbon neutrality is the preservation of the carbon rich forest that occupies south campus.

Although carbon stock is an important part of the forest, there are a number of other key elements to consider when analyzing a forest. The structure of the forest greatly influences the biodiversity and helps power ecological processes (Spies, 1998). Therefore, a healthy forest will have larger species diversity. In addition to determining the health of a forest, an analysis of the species present in a forest can help determine the relative age (Wessells, 1999).

Similar to forest structure, an analysis of the diameter-at-breast-height (DBH) can help determine relative age of the forest. Due to the correlation between tree age and DBH measurements it is possible to estimate the relative age of a forest (Tyrrell & Crow, 1994).

In order to properly analyze the GNA we will calculate the mean carbon stock per hectare as well as the estimated carbon stock. Additionally, we will determine the structure and composition of the GNA in order to determine relative age.

### **STUDY AREA**

The study area for this paper consisted of the entirety of the GNA north of stadium drive. Due to its relatively homogenous structure it was possible to determine the mean carbon stock per hectare and subsequently estimate the total carbon stock.

Fifteen 20m circular plots were set up along two transects and were evenly spaced throughout the GNA to ensure all habitats were taken into account. Plots were chosen in various types of habitats and slopes in order to determine if there was any statistically significant difference between them.

### **METHODS**

To perform this study, a sample size of fifteen twenty-meter plots were taken. These plots lay along two different transects and were evenly spaced throughout the GNA [Figure 1]. Each transect started 20m from the stream and each transect was 100m from the next transect.

The DBH and species type for all trees (living and dead) over 5cm was catalogued in order to calculate carbon stock.

To calculate the mean carbon stock of the GNA, the standards set forth in *Measurement Guidelines for the Sequestration of Carbon* (Pearson et al. 2007) were used. Above ground biomass, total above ground biomass density, above ground carbon stock, below ground biomass density, below ground carbon stock and total carbon stock were calculated. All trees with a DBH of 5cm to 73cm were calculated using the formula  $y = EXP(-2.0127 + 2.4342 \ln(x))$  (Jenkins et al. 2004). All trees with a DBH greater than 73cm were calculated using the formula  $y = 0.5 \left( \frac{25000x^{2.4}}{x^{2.4} + 246872} \right)$  (Brown & Schroeder, 1999).

Once the total carbon stock for all of the plots was determined, 95% confidence intervals were calculated to determine if the plots were statistically similar. Although two of the plots proved to have a statistically significant difference from one another, each plot was over 73% similar to the other plots and therefore both plots were included in the final calculations. The mean carbon stock per hectare was calculated and this data was expanded over the entire northern portion of the GNA. The result was an estimate for the total carbon stock of the surveyed area.

In addition to carbon stock, an analysis of the composition and structure of the GNA were performed by focusing on the species and DBH frequencies. Using this data it was possible to determine the relative age of the GNA.

## **RESULTS**

After the raw data was compiled and analyzed, a statistical analysis of the data was performed. 95% confidence intervals were taken to determine if the plots were statistically similar or not. The result of the analysis showed that 2 of the 15 plots proved to have a

statistically significant difference. Plots 4 and 10 were statistically different but due to the fact that they were statistically similar to 73% and 80% of the plots respectively, they were included in the mean carbon stock calculations [Figure 2]. The mean carbon stock per hectare is 240.468 tonnes. Spreading this data over the 22.87 total hectares of the northern portion of the GNA resulted in an estimated total carbon stock of 5499.502 tonnes.

Tree species records and structure, measured in DBH, yielded analysis in forest composition and forest age. The composition of the Gordon Natural Area proved to be largely American Beach, at 46%. The second most common species was the Red Oak at 16%, followed by the Norway Maple with 13% [Figure 3]. This, in combination with a majority of the trees (55%) having a DBH measurement of less than 20 cm leads to the conclusion that the GNA is a relatively young forest [Figure 4].

### **DISCUSSION AND CONCLUSION**

Although carbon stock is very important, there are several other aspects of a forest that are essential for a complete analysis. The analysis of forest age via DBH and structure via species composition explains a lot about the GNA. By examining the frequency of tree species, it is possible to hone in on the relative age of the forest. The GNA is a predominately hardwood forest composed primarily of American Beech, Norway Maple and Red Oak trees; while species such as White Ash and Tulip Poplar are less frequent. When a forest starts, trees such as White Ash and Tulip Poplar are some of the first to inhabit the area (Wessells, 1999). As time progresses and the living conditions of the forest alter, new trees such as maples, oaks and beeches start to become more prevalent. Due to the aforementioned stratification of species it is reasonable to assume that the GNA has gone through a transition from first succession trees to second and some third succession trees. This places the relative age of the GNA as young and

this is further supported by the analysis of DBH frequencies. Over 55% of the trees surveyed had DBHs less than 20cm. These results are consistent with a young forest. Ultimately, it can be deduced that the GNA is in the early stages of second tier succession.

Although the GNA currently displays a transitional species stratification, an alarming trend is very prevalent. While it has been acknowledged that the age frequency is skewed towards young trees, there are an alarming number of older, first succession trees that are missing. Due to the transitional period the GNA is going through it is reasonable for there to be a plethora of young trees. However, the lack of older first succession trees leads to the conclusion that many of them are dying out. This is further supported by the amount of down and dead trees scattered throughout the GNA. Two possible explanations stem from the increase in deer population and the presence of non-native species (D'Angelo 2009). Further research in to this phenomenon is warranted in order to conclusively explain the factors behind the missing trees.

Over the course of this study, a number of problems arose. The first problem occurred during the selection of the plots. Having reviewed a number of maps, the research team determined what was believed to be the boundary of the GNA. However, upon entering the natural area it quickly became apparent that a barbed wire fence ran through the area and cut off about a quarter of what was thought was part of the GNA. This area was private property, and is owned by the homes that are adjacent to the woods. Therefore this section was omitted from the study. Future research could expand upon the data already collected and allow for the estimation of the carbon stock of the southern portion of the GNA.

The GNA is an important geographical feature to the West Chester University campus and the surrounding community. However, the rise in development around the natural area is

having negative effects on the forest. The forest health is less than ideal and this study shed some light on to the possible factors causing it. It is necessary to take steps toward reversing any anthropogenic damage in order to ensure the forest's prosperity in the future.



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## APPENDIX

Figure 1. Study Area of the Gordon Natural Area

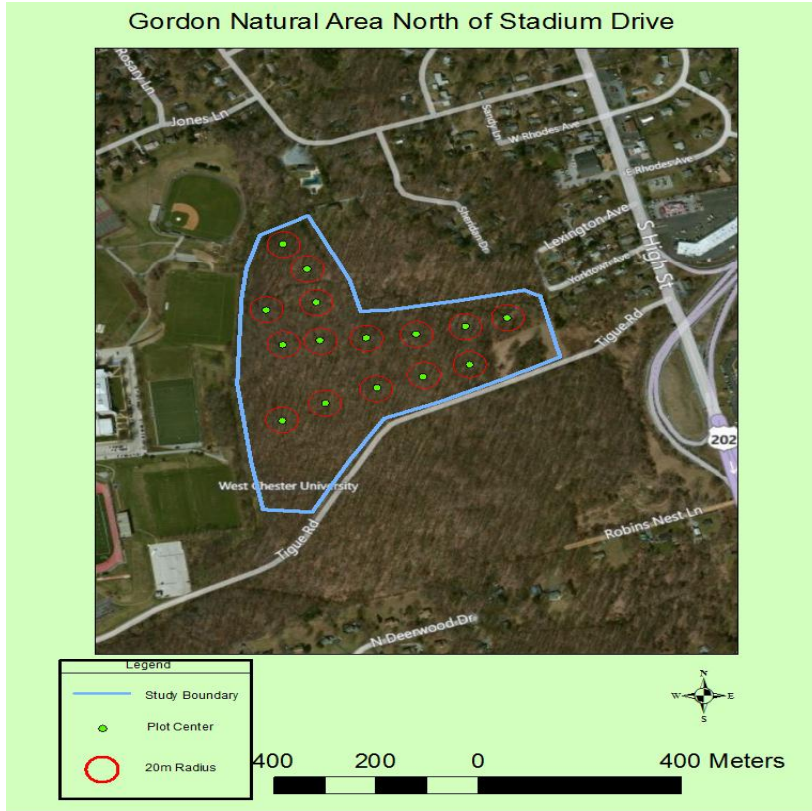


Figure 2. Confidence Intervals for Plots in GNA

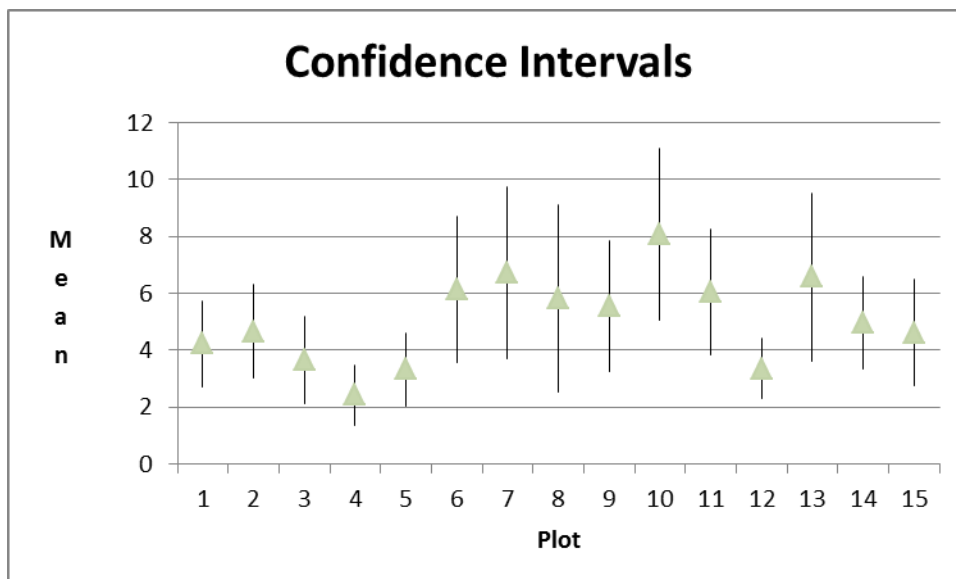


Figure 3. Species Composition of the GNA

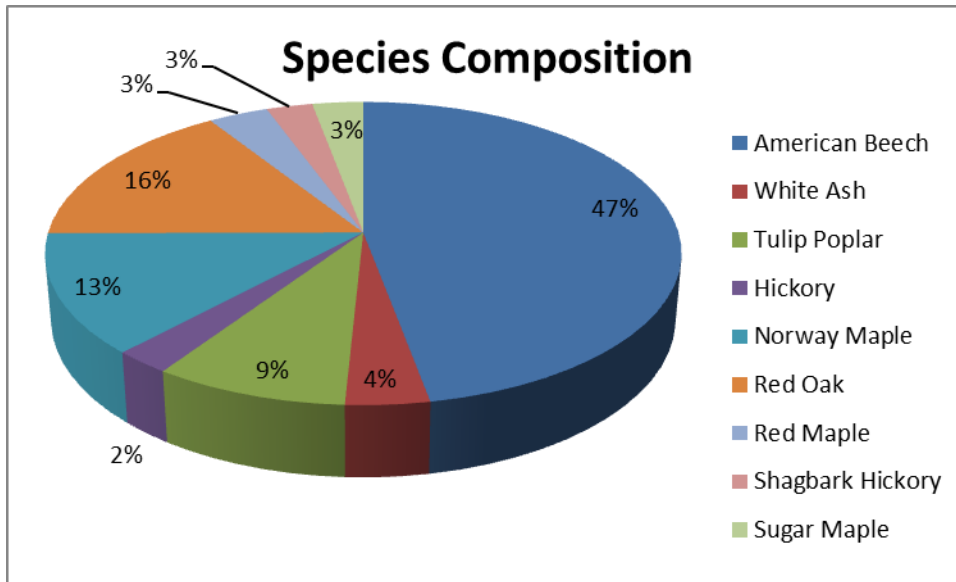


Figure 4. Frequency of DBH Found in the GNA

