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A Value Assessment of the Gordon Natural Area of Environmental Studies at the West Chester University of Pennsylvania

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Abstract

This study is an assessment of several valuing methods of the 61 acres of deciduous forest within Robert B. Gordon Natural Area of the West Chester University of Pennsylvania. The first method used in the study procedure determined an estimated monetary value of standing timber within the deciduous sector of the Gordon Natural Area. Field methodology encompassed the determination of tree species, DBH, and volume in board feet, within twelve ten by ten meter plots. The resulting value of the first valuing method was that the standing timber in the deciduous sector is worth $2,013,992.95. The second valuing method valued the same sector of forest in respect to the annual monetary value of the ecological benefits. The result of this analysis was that the ecological benefits would produce a monetary value of $42,578 annually. While the standing timber value of the deciduous sector of the Gordon Natural Area is staggering, this study concludes that the ecological benefits are more valuable than the monetary worth of the standing timber. This analysis supports the idea that trees are worth much more standing, than cut down for their wood. Ultimately, the Gordon Natural Area should remain a preserved portion of land in which the West Chester community can continue to use as an education and recreational sanctuary. Leaving the trees intact, will provide more to the community and the environment as whole.

Introduction

The West Chester University of Pennsylvania is very fortunate to have a natural sanctuary like the Gordon Natural Area (GNA) in such close proximity to its campus. In 1971 the board of trustees at West Chester University took the initiative of preserving a wonderful and beautiful piece of land in which its primary use would be for educating West Chester students (West Chester University 2012). This preserved portion of land, which includes approximately 61 acres of deciduous forest, would later be deemed the Robert B. Gordon Natural Area for Environmental Studies (West Chester University 2012). The study site for this project involved the deciduous forest sector of the eastern most existing and potential boundaries of the GNA, east of the football field (Figure 1).

If the broad question of, how much is a particular piece of deciduous forest land worth, was asked to several people walking the campus streets of West Chester University, odds are much of the response will involve the value of the trees on that particular plot. One could argue that this assumption may be true for the greater percentage of the human population. Furthermore, if this question took regards to trees independent of the actual land, the unknowledgeable responses would proliferate. How much is that tree worth? Much of the response would most likely range in different monetary values.

Several arguments for a particular plot of land or individual tree worth can be made. Trees are most obviously valuable according to the wood that they provide. A very large portion of today's industry and economy relies on the consumption, use, and sale of wood. Moreover, a tree or piece of land can have value in the ecological benefits that it provides to the environment. The most obvious contributor to the ecological contribution side of the argument is carbon sequestration. A tree or plot of land containing a lot of vegetation will sequester and hold a lot of

carbon. Ultimately, one of the major ecological benefits resulting from trees in this aspect is removing carbon from the atmosphere. While there are many ecological benefits of trees, carbon sequestration is a commonly analyzed ecological benefit of trees, and will be used as an example as an introduction to this study. Deforestation is among the leaders in carbon dioxide emissions worldwide, and trees are a "sink" source for atmospheric carbon dioxide (Bazzaz 1990). A strong correlation between this paper and the main topics in question can be correlated to the deforestation taking place in the tropics. While the physical aspects of a tropical forest may not compare with a deciduous forest, the issues concerning ecological land values coincide.

Tropical trees and forests are being removed from the face of the earth at an alarming rate. Specifically, tropical deforestation accounted for an annual average of nearly 1.5 billion metric tons of carbon dioxide emission during the 1990s (Gullison et al. 2007: 985) A staggering estimation of 87-130 billion metric tons of carbon dioxide emission is expected if deforestation trends continue through the year 2100 (Gullison et al. 2007: 985). Again, the emission of carbon into the atmosphere has drastic negative impact on global warming. Based on this overwhelming factual information in regards to tropical forest, one can understand the tremendous ecological benefit of carbon sequestration for trees and land plots worldwide. While this paper analyzes a small deciduous forest in south eastern Pennsylvania, the importance and value of land plots and trees is easily understood by the comparisons to tropical forests.

This paper will analyze the major questions concerning land and tree value. A common understanding of land and tree value will be brought full circle, and a deeper and more knowledgeable analysis of valuing land will be the major goal of this project. The Gordon Natural Area provides a great study ground to show the importance of understanding the value of trees and land plots. Lastly, it must be understood that this study only takes into account the trees

greater than 16 inches (40 centimeters). Because, there is more vegetative species besides trees within the GNA, much of our data will be of greater significance. A general understanding of the importance of the Gordon Natural Area, concerning both monetary and ecological value, should be easily accomplished by this analysis.

Methods

The determination of the site location for our study was the first step in the experimental methodology. It was determined that the Gordon Natural Area (GNA) will be a viable site location to conduct a prosperous experiment. Twelve total plots sites were analyzed within the GNA. Four plots below the dirt road, four plots above the dirt road, and four plots located in the old apple orchard section of the GNA were the site locations of our study. These different locations provided a variety different terrain, species, density, and overall environment to encompass the various land types in the GNA. Each plot was randomly selected within the GNA. Exact locations were determined by simply walking in the GNA and choosing a particular area to place a 10 x 10 meters squared plot. To ensure accuracy and consistency, plot area was determined using several important steps. First, a designated starting point for each plot was determined. A small metal stake was pushed into the ground, and the stake was used as the fulcrum for a 90 degree angle. While standing at the stake, a compass was used to establish the direction in which the next two plot corners would be located. 10 meters were marked off in both directions, and each new point was marked using spray paint. Again, a compass was used to create a right angle for locating our last corner location for our 10 x 10 meter squared plot. With the plot location and size determined, each tree with a DBH larger than 16 inches was identified using colored ribbon. The parameter of a minimal DBH of 16 inches was determined, because the minimum tree size characteristics for hardwood sawtimber logs are greater than or equal to

16” DBH (Bardon n.d.). Each accepted tree was identified for species type, measured for DBH, the amount of sawtimber logs contained within the tree, and the tree volume in board feet was determined. Tree species identification was done by all group members, with assistance from George A. Petrides’ “Tree and Shrubs Field Guide”. DBH was measured using a Forestry Supply Inc. DBH Tape. The amount of sawtimber logs contained within each tree was be determined by using Tree Scale Stick-Scribner Rule (FC-78). Tree scale sticks were used by standing approximately 66ft from the base of the tree. Each group member paced off their given amount of steps to determine their approximation of 66ft. When pacing away from the tree, it was of primitive importance to remain at the same elevation of the base of the tree. Once the approximate 66ft was paced off, the tree scale stick allows you to look at the tree, hold up the stick, and record the amount of logs within the target tree. The amount of board feet within a tree was determined by using the table on the side of the tree scale stick, logs were the x axis, DBH was the y axis. Logs were matched up with the DBH according to the tree in question, and the board footage was the intersecting value on the table. Data was collected for statistical analysis and comparison between each plot and plot areas.

To calculate the estimated value of each tree, The Pennsylvania Woodlands Timber Market Report was analyzed and used to asses our data. The timber market report gives prices based on average timber prices per one thousand board feet (Pennsylvania Woodlands 2012). Since each tree had varying board footage values and equation was applied to our data to coincide with the market prices. The average market value prices according to species were multiplied by the actual board footage of each individual tree. Lastly, the resulting value was divided by 1000 to yield the final value per tree. Individual tree values were summed to yield

total plot worth, and moreover, the plots within each study area were summed for a total plot value.

A statistical test using the data analysis tool on Microsoft Excel was applied to the plot values as a whole. Mean and coefficient values were the most important values from the statistical test. The mean was added and subtracted from the coefficient value to get high and low coefficient values. These new high and low coefficient values determined whether the plots were statistically significant or not. Lastly, all the plot values were averaged. This new average as used for the final calculation to determine the estimated worth of the GNA. Since the individual plots had an area of 100 meters squared, for the GNA area (61 acres) was converted to meters squared (West Chester University 2012). The estimated overall value of the GNA was equated using a ratio cross multiplication problem. Average worth of the individual plots was multiplied by the overall area of the GNA. The resulting value was then divided by 100 to yield the final dollar worth of the GNA.

The final calculation for the project was the determination of the monetary value for the ecological benefits of the GNA. The annual monetary value of $698 per acre of deciduous forest was used for the calculation (Paul 2011). Since the GNA contained 61 acres of deciduous forest, 61 was multiplied by $698, to yield the ecological dollar value of $42,578 for the GNA annually (Table 4).

After data crunching and calculating was completed, a map was created from the GPS points that were collected on the corners of each plot. The coordinates were imported from an Excel Sheet into ArcMap. The appearance of the map was disoriented, so some editing was needed. The locations were not perfectly square because of slight GPS errors, so to make precise

squares in the plot locations, multiple ArcMap tools were applied to the geospatial data. First, the aggregate points tool to create polygons from our points and used a tolerance of 10 meters, so that only the points from each plot would be joined. These polygons were all randomly shaped, so to create squares the "polygon to points" command was used to create a centroid of that polygon. This gave us the center of where the polygon was to be located. Next, a five meter buffer was applied to those centroids. 5 meters was used because our plots were 10 meters by 10 meters. Two five meter radii equates to a 10 meter diameter for our plot. Feature envelope to polygon tool enabled the buffer to become a square polygon. This resulted in the finalized square plots within a precise distance from our original GPS locations. The file was exported to KML to be viewed in Google Earth, as well; this gave yielded a better view and base map of the study area. Each area (Above Road, Below Road, and Apple Orchard) was symbolized, along with the drawn lines along the roads, to decipher each area. Above the road plots were symbolized as blue squares, below the road plots were symbolized as red squares, and the apple orchard plots were symbolized with yellow squares (Figure 2).

Results

The gathered data for the project yielded conclusive evidence for all of the questions being asked. The estimated value of trees in the Gordon Natural Area based on saw timber logs was $2,013,992.95 (Table 4). An average value of $815.85 was calculated for the 12 10 by 10 meters within the three distinct areas in the GNA (Table 1). There was no variation in regards to tree value throughout the Gordon Natural Area. Furthermore, it can be concluded that based off of historical land use, the GNA has no variation (Table 3, Figure 3). The high and low confidence interval calculations determined that there was no significant from the plots based on a 95% confidence value (Table 3, Figure 3). From this data, it was conclusive that varying

disturbance levels and the history of the GNA do cause variation in tree value. The ecological benefit value was estimated at $42,578 (Table 4) per year. This will surpass the saw timber value within 47 years, and the Gordon Natural Area has been preserved since 1971 (41 years). Conclusive evidence can be drawn in support of the fact that the GNA is worth more ecologically than monetarily in terms of standing timber.

Discussion

The questions that were in discussion for this project was first, what is the estimated value of trees in the Gordon Natural Area? What is the estimated total worth of the Gordon Natural Area? Does the value of trees vary according to historical land use? Are the trees in the Gordon Natural Are more valuable as timber or for their ecological benefits? The first question that the project addressed was what is the estimated value of trees in the Gordon Natural Area (GNA)? For this question, a broad understanding of individual tree worth within the GNA was the major goal. Understanding individual tree worth was the foreground for this project. All conclusions that can be drawn from this experiment stem from the initial tree values, so the first question was of utter importance. Drawing from past experiences and the initial review of wood prices in the Pennsylvania Woodlands Timber Market Report, the group hypothesized that the average value of individual tree worth would be approximately $200.00 (Pennsylvania Woodlands 2012). It was understood that different species of trees would vary in standing lumber cost, which was measured by a monetary value per board foot of wood. The hypothesis of $200.00 per tree was a general estimate, because it was understood that the GNA encompassed a variety of different, large trees. The methods used to collect the field data allowed a definite conclusion to be drawn regarding the first question. With the data compilation of individual tree worth, an average value of $208.30 was calculated and used in support of the

initial question (Table 1). The hypothesis for individual tree worth was very accurate and an understanding of the basis of the project was unambiguous. Stemming from individual tree worth was the second question of the project. What is the estimated overall worth of the GNA? This question takes into account the 61 acres of deciduous forest in the GNA, and only those trees with a DBH of at least 16 inches (approximately 40 cm) that lie within that designated area. To reiterate, it is important to understand that area of the GNA in question for this project is strictly the standing deciduous forest sector. The standing deciduous forest portion of the GNA encompasses 61 acres of land, and this is the portion of land that this project takes into account (West Chester University 2012). The averaged individual tree worth values, in conjunction with field observations of the environmental characteristics of the GNA, determined the hypothesis for overall GNA worth. It was hypothesized that the Gordon Natural Area would be worth approximately ***$250,000***. According to the calculations, previously described in the project methods, the Gordon Natural Area is worth approximately $2,014,000.00 in standing timber**.** The hypothesis for overall worth was significantly low in comparison to the actual calculated value.

Since the individual worth of trees, and the overall estimated value of the GNA were understood, analysis involving the 10 by 10 meter plots was able be conducted. The third question of the study was, does the value of trees vary according to historical land use? We hypothesized that the value of the GNA would be significantly different based on location of the plot. For example, we hypothesized that the apple orchard would have the smallest and least valuable trees due to the minimal limitations human activity on those grounds. Furthermore, this area used to be an apple orchard, so there would be some limitation in species variation do the succession of that particular forest. Below the road would have been valued in the middle due to the obvious amount of human disturbance such as the walking trails, although there seemed to be

much less disturbance in this area than the apple orchard section. And lastly, above the road would have been most valuable due to its size and limited amount of human disturbance. Though we were correct in assuming that the plots above the road were the most valuable, there is nothing, other than random chance, that explains the slight variation in the value of each area (Table 2). Thus we can conclude, with 95% certainty, that there is no statistical difference in the values of the plots measured (Table 3). High and low confidence intervals were calculated, and no significant difference was found for the analyzed plots within the three different areas. The insignificant differences between the plots were also evident based on the overlap of high and low coefficient values, and since all values overlapped, no significance could be determined (Figure 3).

The final question analyzed for this project involves the ecological value of the GNA compared to the monetary value of standing timber in the GNA. The hypothesis for this question was that the GNA would be worth more ecologically, when compared to the standing timber value. Since the estimated value of the GNA in terms of standing timber was understood, a method to analyze the ecological value of the GNA was needed. A study where deciduous forest was valued for nine different ecological benefits was used as the fulcrum to conclude the final question. The nine different ecological benefits encompassed within the ecological value assessment are water quality, water supply, pollination, recreation, forest products, farm products, disturbance prevention, habitat, and carbon sequestration (Paul 2011). Furthermore, for deciduous forest, the ecological benefits are estimated to be approximately $698 per acre (Paul 2011). It must be understood that the value of $698 is an annual monetary value used to assess the ecological benefits of deciduous forest. With a set value for deciduous forest per acre is understood, a calculation for the estimated ecological value for the GNA can be made. Since the

GNA area of deciduous forest is 61 acres, the multiplication of the area and ecological value per acre, based on the monetary value of the nine parameters, yields the ecological value for the GNA. The methods used to explain the final ecological calculation yielded a value of $42,578.00 annually for the GNA (Table 4). Since the estimated value of standing timber for the GNA is roughly $2,014,000.00; and the annual ecological benefit value is $42,578.00, a final comparison between ecological and standing timber value can be drawn. When dividing the standing timber value by the annual ecological value, it was found that the ecological benefits will reach the value of the standing timber value after 47 years (Table 4). This fact was relevant to the project because West Chester inherited the GNA in 1971, and the ecological benefits have almost reached the value of standing timber (West Chester University 2012).

When analyzing the final values for the GNA it was undeniable that the GNA was truly a highly valuable piece of land. Although the standing timber value of the GNA is astonishing, the ecological value is more significant. The ecological value is an annual value, and will eventually surpass the standing timber value. Moreover, despite the succession of the monetary value, the environmental impact is significant. Environmental benefits for the trees in the GNA involve the nine parameters used to determine the value of deciduous forest. These parameters make the environment and the forest itself a much healthier ecosystem, and will be much more beneficial, in terms of value, than the monetary value of the standing timber.

Conclusion

Several obvious conclusions can be drawn from this assessment. First and most apparent, the Gordon Natural Area is highly valuable. Whether talking about the standing timber or the ecological benefits of the deciduous forest section of the GNA, the understanding of value is

evident. This study argues that the ecological benefits of the GNA are much more valuable than the standing timber value. The ecological benefit calculations for this study are on an annual time scale, meaning that their benefit is continuous. After about 47 years the ecological benefits will have yielded a higher monetary value than the standing timber value. Standing timber only accounts for an upfront benefit, a dollar amount when trees are cut down. The ecological benefits encompass much more than a set monetary value. Environmentally, the trees within the deciduous forest sector of the GNA will account for many different ecological benefits. Water quality, water supply, pollination, disturbance prevention, habitat, and carbon sequestration are some of the many ecological parameters that these trees will include (Paul 2011). Likewise, it must also be understood that there is educational value within the GNA. While this study does not divulge a lot of literature on the educational value of the GNA, it could arguably be one of the most important aspects of the area. West Chester University is very fortunate to have this area for use by its students. Since the preservation of this land, West Chester University has been using the GNA to educate undergraduate and graduate students. Lastly, the final conclusion that can be drawn from this assessment is the recreational value of the GNA. Many people enjoy going on walks and enjoying the beauty of nature within the GNA. The preserved portion of land has enable people to enjoy the many wonders of the outdoors. Regardless of the wide array of conclusions that can be drawn from this assessment, the GNA should remain a preserved portion of land in which ecological benefits, recreational activities, and education uses can flourish.

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Table 1

Apple Orchard Trees			**Above Road Trees**		
Tree #	**Speices**	**Tree Value ($)**	**Tree #**	**Speices**	**Tree Value ($)**
1	Tulip Poplar	187.62	1	Red Oak	1002.81
2	Tulip Poplar	79.77	2	Norway Maple	263.76
3	Tulip Poplar	96.52	3	Tulip Poplar	220.19
4	Tulip Poplar	173.70	4	American Beech	25.44
5	Tulip Poplar	245.91	5	Red Oak	149.97
6	Tulip Poplar	85.90	6	Red Oak	149.97
7	Tulip Poplar	37.05	7	Tulip Poplar	416.78
8	Tulip Poplar	131.69	8	Tulip Poplar	174.64
9	Tulip Poplar	75.99	9	Tulip Poplar	243.55
10	Tulip Poplar	311.99	10	Tulip Poplar	223.02
11	Tulip Poplar	333.70	11	White Oak	177.33
12	Tulip Poplar	126.50	12	Tulip Poplar	371.94
13	Tulip Poplar	174.64	13	Tulip Poplar	114.70
14	Tulip Poplar	226.32	14	Red Oak	545.90
15	Tulip Poplar	49.80	15	Red Oak	590.81
16	Tulip Poplar	108.09	16	Tulip Poplar	265.26
Below Road Trees			17	Tulip Poplar	90.15
Tree #	**Speices**	**Tree Value ($)**	18	Tulip Poplar	68.20
1	American Beech	166.72			
2	American Beech	108.16			
3	American Beech	65.76			
4	Tulip Poplar	355.42			
5	American Beech	89.28			
6	American Beech	98.72			
7	Tulip Poplar	209.10	**Overall Average Tree Value**		**208.30**
8	Red Oak	395.11			
9	Red Oak	335.37			
10	Tulip Poplar	75.99			
11	Tulip Poplar	58.29			
12	Tulip Poplar	202.49			
13	Tulip Poplar	90.15			

Table 1: Depicts the overall average tree value, calculated from individual tree values.

Table 2

Plot #	Apple Orchard	Above Road	Below Road
1	537.608	1512.196	340.64
2	368.868	1134.904	543.416
3	979.872	886.979	1015.564
4	558.848	1560.328	350.932
Total	2445.196	5094.407	2250.552

Table 2: Plot values were determined based on the summation of trees within each plot. The total monetary value for each area was determined by the summation of the values for the four plots.

Table 3

Apple Orchard		*Above Roac*			
Column2 Apple Orchard		***Column3 Above Road***		**Column3 Below Road**	
Mean	611.299	Mean	1273.60175	Mean	562.638
Standard Error	130.0001016	Standard Error	160.1700594	Standard Error	158.0121275
Median	548.228	Median	1323.55	Median	447.174
Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	260.0002032	Standard Deviation	320.3401189	Standard Deviation	316.024255
Sample Variance	67600.10566	Sample Variance	102617.7917	Sample Variance	99871.32973
Kurtosis	2.50768288	Kurtosis	-3.144913775	Kurtosis	2.046972038
Skewness	1.338047807	Skewness	-0.472624203	Skewness	1.530918539
Range	611.004	Range	673.349	Range	674.924
Minimum	368.868	Minimum	886.979	Minimum	340.64
Maximum	979.872	Maximum	1560.328	Maximum	1015.564
Sum	2445.196	Sum	5094.407	Sum	2250.552
Count	4	Count	4	Count	4
Confidence Level(95.0%)	413.718343	Confidence Level(95.0%)	509.7326138	Confidence Level(95.0%)	502.8651113
HIGH AND LOW CONFIDENCE INTERVAL CALCULATION BELOW					
Mean	611.299	Mean	1273.60175	Mean	562.638
Confidence Level(95.0%)	413.718343	Confidence Level(95.0%)	509.7326138	Confidence Level(95.0%)	502.8651113
plus	1025.017343	plus	1783.334364	plus	1065.503111
minus	197.580657	minus	763.8691362	minus	59.77288869

Table 3: The table produced from the data analysis ran on the four plots within each area, Apple Orchard, Above and Below Trail. The table depicts final calculation values from the high and low confidence interval calculations.

Table 4

Area GNA (acres)	Area of Ecological Benefits (acre)	Timber Value GNA	Ecoligical Value ($/acre)	GNA Ecological Value	Years for Equivalence
61	1	2013992.95	698	42578	47

Table 4: The tables shows the values for the calculations used to determine the ecological value of the GNA. The GNA has an area of 61 acres. The value used to determine the ecological value of the GNA is the $698/1 acre. This value was taken from the report by the Piedmont Environmental Council for deciduous forest. Years of equivalence represents the time period in which the ecological value will equal the monetary standing timber value.

Figure 1

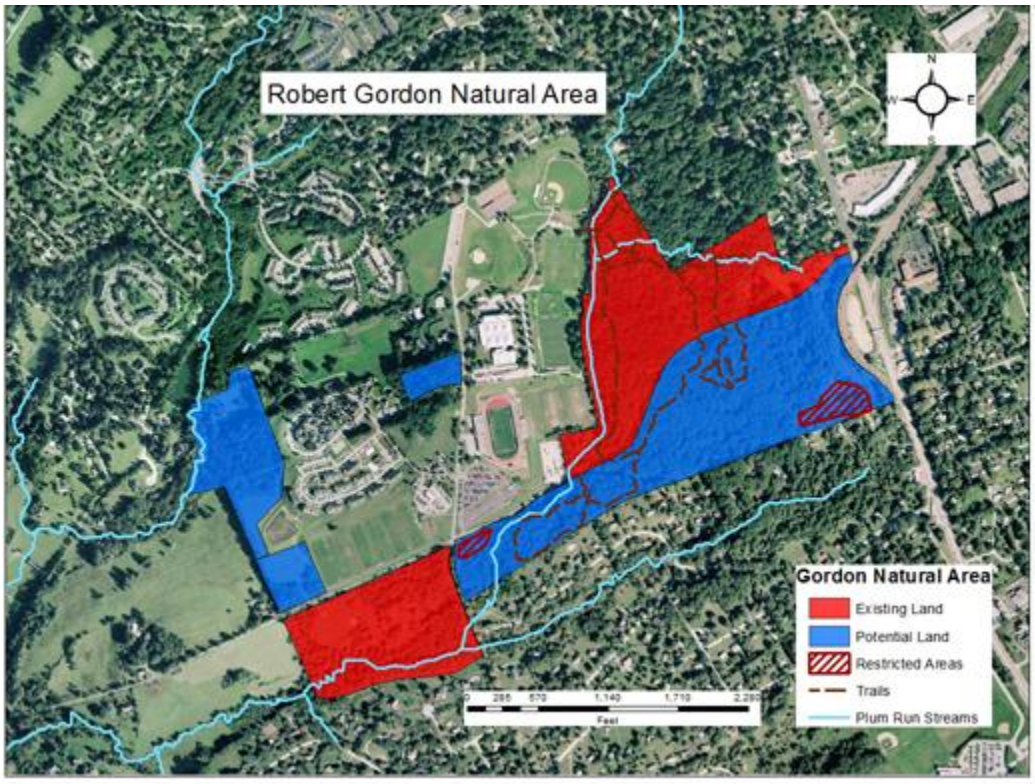

Figure 1: A visual provided by West Chester University of the Existing and Potential boundaries of the Robert B. Gordon Natural Area. The study locations for this project lie within the large blue and red polygons/plots, east of the football field. http://www.gordonarea.org/lands.html

Figure 2

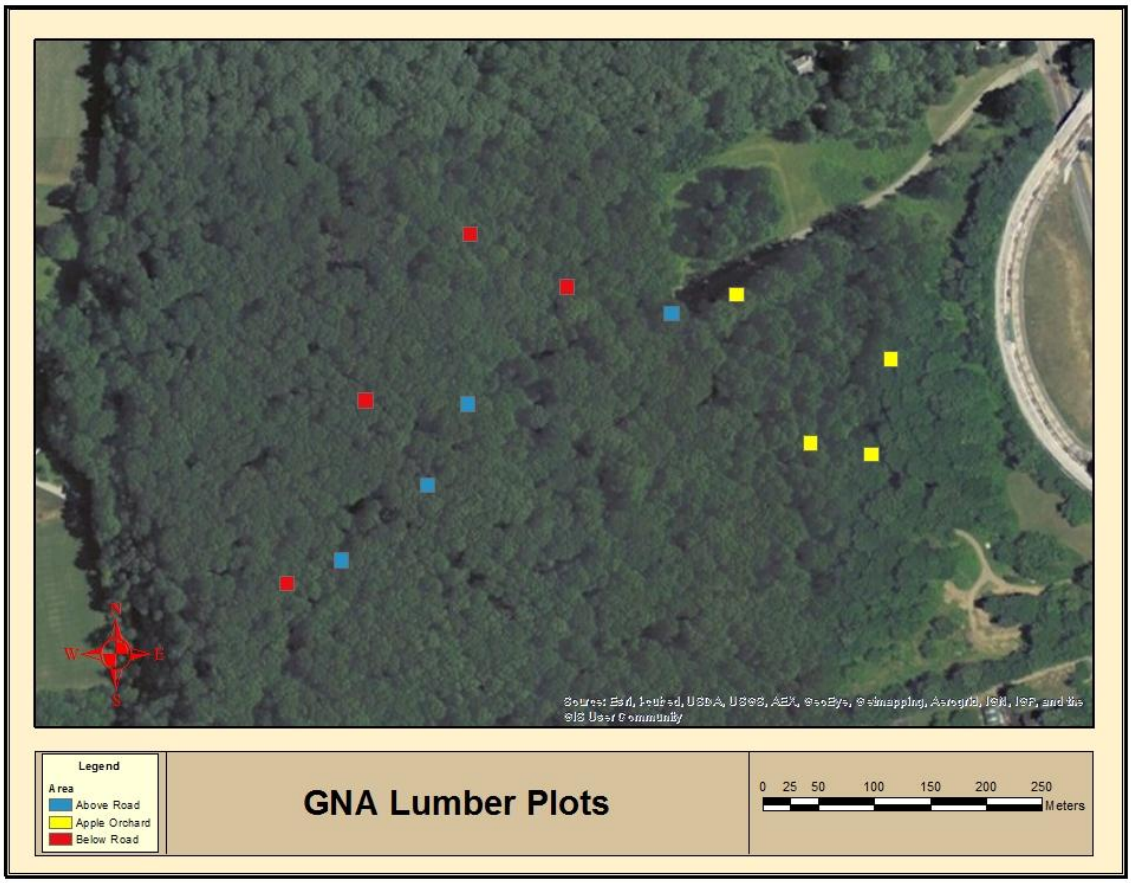

Figure 2: This map shows the plot locations for the study, located in the Gordon Natural Area on the south campus of West Chester University.

Figure 3

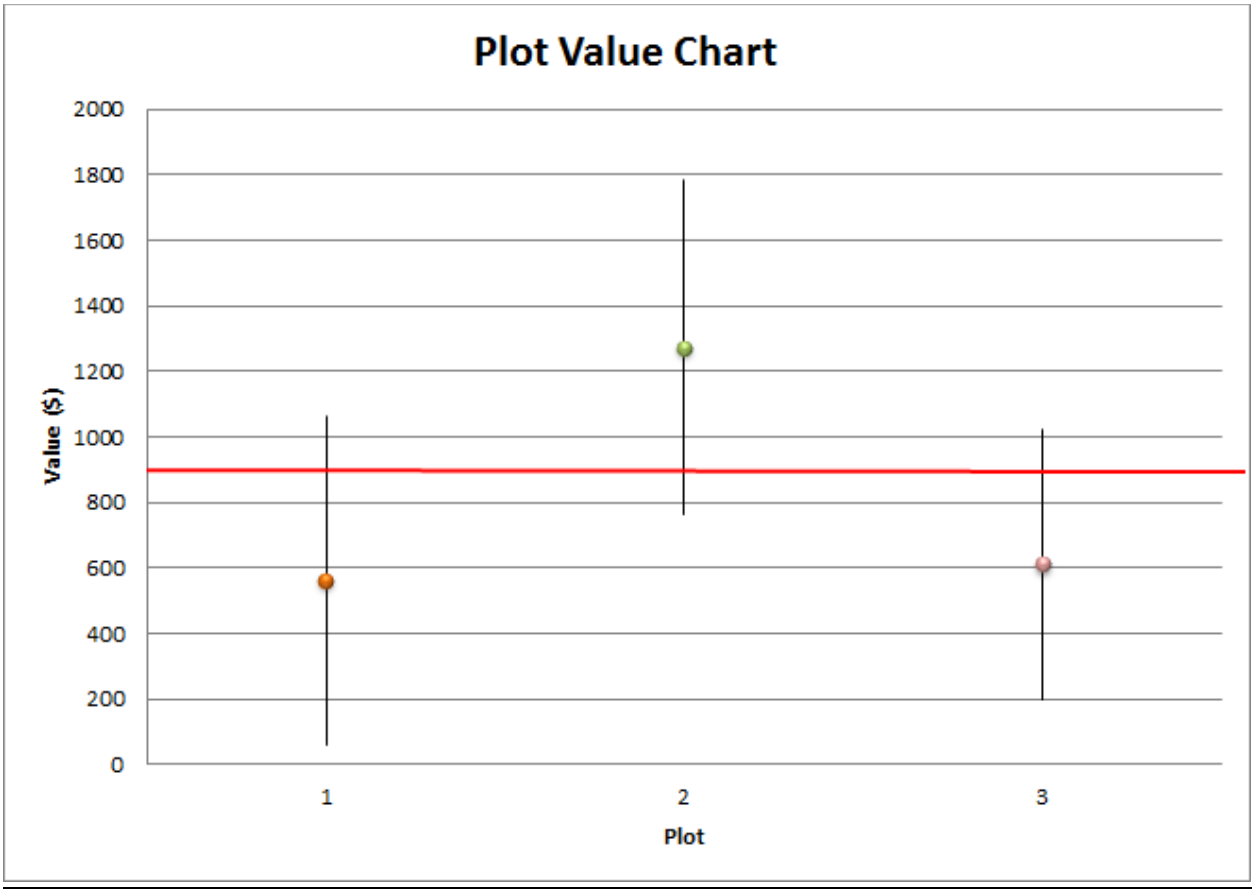

Figure 3: Represents the graph produced from the high and low coefficient values for the three plots. The red line symbolizes a common value in all three areas analyzes, and proves that there is a definite overlap in all three plot areas.