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The Changes in Woodlot Land Cover from 1988 to 2006 within Private/Farmland in Hancock County, Ohio

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The Changes in Woodlot Land Cover from 1988 to 2006 within Private/Farmland in Hancock County, Ohio

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Department of Geography

Honors Research Project

Submitted to
The Honors College

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Reader (signed)

Accepted:

______________________ Date ________
Department Head (signed)

______________________ Date ________
Honors Faculty Advisor (signed)

______________________ Date ________
Dean, Honors College
Introduction

Background

Historical clearing of forested land for agriculture contributed to broad-scale ecological change and many environmental problems in the United States (Williams 1989; Whitney 1994; Leopold 1999). One of these factors is the increased amount of soil erosion which threatens the food production capacity of the land. Human disturbance, more than any other factor has had an impact on the distribution of vegetation in Ohio today (Barrett, 2008). Early settlers in the United States wasted little time in the removal of areas of thick woodland. Trees were removed and the rich soil plowed in order to produce the necessary food. Trees during these times in the 19th century disappeared rapidly for fuel, fencing, sawed lumber, and for export; often, areas were burned merely to create widespread clearing. (Conzen 1980).

Ohio is part of the eastern deciduous forest, which once covered most of the land area of the United States east of the Mississippi River. Soils within these forests are fertile. During the arrival of the early settlers in Ohio only 4% of the land was not covered by forest. This changed by 1880 where a staggering three quarters of the land area had been cleared for other uses (Barrett, 2008). The clearing of forested areas began to change at the turn of the 20th century as marginal farmland was abandoned and reverted back to forested area. This clearing trend however, did continue in the first half of the 20th Century in the northwestern region of the state as communities settled late in this area, however the rest of Ohio experienced a gradual increase in forested land from 1900 until the present day (Barrett, 2008). The return of forests has been
most prominent in the southeastern portion of the state, which is less suited for agricultural uses. On the other hand, in the northwestern portion where the land is especially well suited to support crop production, the return of forested areas in less prominent. Due to the vast scale of human disturbance in Ohio’s forested areas, most of today’s forests are only in their early successional stages.

The question of changes in woodlot land cover is important in today’s day and age as it can give an insight into the reliance on the land for food production that occurs in Ohio. Also this question shows how the dependence on the resources provided by forests are changing as new industries and materials are being produced in our ever developing world.

**Research Question**

The research question for this project is, How has woodlot land cover has changed within private farmland in Hancock County, Ohio between 1988 and 2006? The project aims to represent how woodlots have increased or decreased from 1988 to 2006. Following the trends expressed throughout the 20th century to the present day, it is expected that there will be an increase in the woodlot land cover area from 1988 to 2006. The reason for only focusing on private land is due to most woodlots in Ohio being privately managed on farmland. Privately managed woodlots are not protected like ones situated in public lands, therefore changes are much more likely to occur. From looking at these particular woodlots we are able to view how woodlots are privately managed in Ohio. (Figure 1) shows the location of Hancock County within the state of Ohio.
There are two study areas which will be focused on within Hancock County (Figure 2). The study area situated in the western portion of Hancock County will be referred to as Study Area 1 and the study area situated in the southeastern location of Hancock County will be referred to as Study area 2 throughout the analysis.
Methods

Digital Orthophoto Quadrangle (DOQ) images were obtained from the United States Geological Survey (USGS) Earthexplorer website. A DOQ is a computer-generated image of an aerial photograph in which the image displacement caused by terrain relief and camera tilt has been removed. The DOQ combines the image characteristics of the original photograph with the
georeferenced qualities of a map (USGS). The DOQ images obtained were from the 17th April 1988. Eight separate images were obtained to cover Study Area 1 in Hancock County and six DOQ images were obtained to cover the Study Area 2.

Once the data from 1988 was downloaded, the next step was for each image to go through image segmentation. Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels). The goal of segmentation is to simplify the representation of an image into something that is more meaningful and easier to analyze. In this project the images were segmented using eCognition Developer 9.0 using a multiresolution segmentation algorithm, with a scale parameter of 100, shape parameter of 0.1, and compactness parameter of 0.5. A preliminary classification into "woodlot" and "not woodlot" classes was accomplished by categorizing all image objects with a mean pixel value of less than 110 and a standard deviation of more than 6.5 as trees; all other segments were included in the "other" class. The resulting image segment classification was exported into shapefile format. (Figure 3)

Once each image was segmented, the polygon shapefile of segments was opened in ArcMap alongside the corresponding DOQ image. Each segment in the analysis area was checked to see if it had been classified correctly and any incorrectly classified segments were corrected. Since in this project, the DOQ images were in black and white, many agricultural cropland, housing and waterbodies which appeared dark on the image were incorrectly placed into the woodlot class.
A formal accuracy check was conducted on the corrected image segments. To do this the ‘create random points’ tool was used to generate fifty points constrained within each DOQ image. Once generated, each point was individually classified to Woodlot or Not Woodlot. To find the accuracy of the segmentation classification, the accuracy points and the segmented shapefile...
were combined using the’ intersect’ tool so that the location of each point could be compared to see whether the classification of the shapefile matches the real life truth of the points. The four possible outcomes from this comparison of each point which were (classified as woodlot — real life woodlot), (classified as other land use — real life woodlot), (classified as woodlot — real life other land use) and (classified as other land use — real life other land use) were used to generate a formal accuracy check table for each study area.

The classified image segments from 1988 were then compared to a detailed 2006 classification (Barrett, 2016). The 2006 data was generated from LIDAR data with two meter nominal post spacing. LAS points classified as vegetation were used to generate an elevation raster with 10 foot cells, then reclassified such that cells with elevation values were identified as woodlots, and cells without elevation were identified as ‘not woodlot’. The woodlot class was filtered spatially to avoid small, scattered woodlot areas and eliminate occasional holes in the middle of woodlot areas (Barrett, 2016).

Firstly, to compare both datasets, the ‘Merge Tool’ was used to combine the eight segmented polygon shapefiles for Study Area 1 and the six shapefiles for Study Area 2, to combine the classified polygons into one shapefile over the study area locations. As the segmented polygons were still in a vector format, the ‘Polygon to Raster’ tool was used to rasterize the recently merged Study Areas 1 and 2 segmented shapefiles. Within this tool the processing extent was set to the same as the study area and the snap raster and cell size were matched to the 2006 data provided.
The data was simplified into a raster of each study area in 1988 and a raster from each study area in 2006, showing two classes of ‘Woodlot’ and ‘Other Land Use’. The ‘Combine Tool’ was used to compare the differences of change from both analysis areas. Four classes were produced from this tool were: Woodlot to Woodlot, Other Land Use to Woodlot, Woodlot to Other Land Use and Other Land Use to Other Land Use and from the number of pixels provided in each class, the total area of each class could be calculated.

All public and urban land areas were excluded from the analysis with only private agricultural lands the focus of this study. Private agricultural lands were defined as land that meets all of the following criteria: not state owned in the Ohio Department of Natural Resources’ GIMS database; not identified as ‘protected’ land in the USGS GAP Analysis Protected Areas database; not identified as an urbanized area in 2015 TIGER data; not identified as part of a U.S. Census ‘place’ in the 2010 TIGER data and not water in the National Hydrography Dataset (Barrett, 2016). The 1988, 2006 and Ohio Public/Private land datasets were then combined using the ‘Combine Tool’ to produce a map showing the changes from 1988 to 2006 within the private lands in the Study area. Four classes were again produced from this combine: (Private Land, Not Woodlot in 1988, Not Woodlot in 2006), (Private Land, Not Woodlot in 1988, Woodlot in 2006), (Private Land, Woodlot in 1988, Not Woodlot in 2006) and (Private Land, Woodlot in 1988, Woodlot in 2006).
**Formal Accuracy Check**

The formal accuracy check showed that 97.3% and 98.5% of the points were correctly classified (Tables 1 and 2). The formal accuracy check shows that classification of the 1988 data was done to an adequate standard.

**Table 1 - Formal Accuracy Check Study Area 1**

<table>
<thead>
<tr>
<th>Use</th>
<th>Classified as Woodlot</th>
<th>Classified as other Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodlot</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Other Land Use</td>
<td>0</td>
<td>380</td>
</tr>
</tbody>
</table>

Formal Accuracy = 98.5%

**Table 2 - Formal Accuracy Check Study Area 2**

<table>
<thead>
<tr>
<th>Use</th>
<th>Classified as Woodlot</th>
<th>Classified as other Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Life Woodlot</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Real Life Other Land Use</td>
<td>6</td>
<td>269</td>
</tr>
</tbody>
</table>

Formal Accuracy = 97.3%
Study Area 1 Results

Study Area 1 Woodlot Locations — 1988 Data

Figure 4 — Study Area 1, 1988 Data Woodlot Locations.
Study Area 1 Woodlot Locations — 2006 Data

Figure 5 — Study Area 1, 2006 Data Woodlot Locations.
The study area 1 results, show that the proportion of Woodlot land use has increased between 1988 and 2006. (Figures 4 and 5) (Table 3).

### Table 3 - Land Cover Hectares, Percentage and Change of Study Area 1 in 1988 and 2006

<table>
<thead>
<tr>
<th></th>
<th>Woodlot</th>
<th>Other Land Use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hectares</td>
<td>Percent</td>
<td>Hectares</td>
</tr>
<tr>
<td>1988</td>
<td>593.64</td>
<td>38.41</td>
<td>951.89</td>
</tr>
<tr>
<td>2006</td>
<td>686.57</td>
<td>42.14</td>
<td>942.87</td>
</tr>
<tr>
<td>Change</td>
<td>92.93</td>
<td>3.73</td>
<td>-9.02</td>
</tr>
</tbody>
</table>

The study area 1 results, show that the proportion of Woodlot land use has increased between 1988 and 2006. (Figures 4 and 5) (Table 3).

**Introduction of Ohio Public/Private Data into the Analysis**

As this project is interested in the changes of woodlot within the private (farmland) land within each study area, the introduction of the Ohio Public/Private Data was combined with the 1988 and 2006 rasters of each study area. (Figure 6 and Table 4) show the combined data representing the changes occurring with the private land in Hancock County.
Table 4 — Land Cover Area Table including Private Land (Study Area 1)

<table>
<thead>
<tr>
<th>Classification of Private Land</th>
<th>Area (Hectares)</th>
<th>Percent of Private Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Land - Not Woodlot in 1988 - Woodlot in 2006</td>
<td>176.30</td>
<td>10.49</td>
</tr>
<tr>
<td>Private Land - Woodlot in 1988 - Not Woodlot in 2006</td>
<td>71.50</td>
<td>4.26</td>
</tr>
<tr>
<td>Private Land - Not Woodlot in 1988 - Not Woodlot in 2006</td>
<td>929.10</td>
<td>55.32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1679.61</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

Figure 6 — Study Area 1 Combination Map of 1988, 2006 and Ohio Private Land Data
**Study Area 1 Analysis**

From looking at (Figure 6) and (Table 4), we can see that the area of private land which is classified as woodlot in 2006, whether it changed to woodlot or remained woodlot from 1988, covers 40.42% of the land. The patterns which have occurred in Study Area 1 show that the changes from other land use to woodlot from 1988 to 2006 are occurring on agricultural land between woodlots that were present in 1988. In the central northern portion of (Figure 6) there is a large proportion of the (Private Land/Not Woodlot in 1988/Woodlot in 2006) class visualized on the map as the pink colored classification. This area within Hancock County is mainly agricultural and with Ohio in the past half a century moving away from the reliance on agriculture and opened spaced land, these areas have experienced the process of succession into brush and eventually mature forested areas. Due to agriculture being a disturbance to the land in these areas, the natural ecosystem was out of equilibrium. However following the removal of the agricultural practices the natural processes of the ecosystem have slowly worked to restore the equilibrium in these areas. As these areas in Study Area 1 are in a location surrounded by existing woodlot locations, the process of succession has occurred at a much greater rate.

Another pattern occurring in Study Area 1 is the returning of woodlots along the river valley bed. The Ohio Tree Farm program is the application of the American Tree Farm System (ATFS) to Ohio and looks to maintain sustainable forests and promote the growing of renewable forest resources on private land while protecting environmental benefits. One of the factors of this association is the management of forests for the protection of water. Many trees have been
planted in Ohio in order to protect water bodies themselves as well as reduce the risks of flooding and wildlife which are reliant on the water body.

The other small changes which have occurred in Study Area 1 which are scattered throughout the area could be due to problems with classification differences between the two datasets. The 1988 data was classified using black and white DOQ images which were not of the best quality compared to the 2006 data collected from LIDAR. The main area you can see this problem is also along the river bed where the river itself was classified as woodlot in 1988 but not in 2006. Due to the color of water and woodlots being similar in the DOQ, the ability to distinguish between these two features was difficult leading to the classification problem between the two datasets.
Study Area 2 Results

Study Area 2 Woodlot Locations — 1988 Data

Figure 7 — Study Area 2, 1988 Woodlot Locations
Figure 8 — Study Area 2, 2006 Woodlot Locations
The study area 2 results also show that the proportion of Woodlot land use has increased between 1988 and 2006. (Figures 7 and 8) (Table 5).

<table>
<thead>
<tr>
<th></th>
<th>Woodlot</th>
<th>Other Land Use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hectares Percent</td>
<td>Hectares Percent</td>
<td>Hectares Percent</td>
</tr>
<tr>
<td>1988</td>
<td>804.61 47.09</td>
<td>903.93 52.91</td>
<td>1708.54 100.00</td>
</tr>
<tr>
<td>2006</td>
<td>904.58 50.29</td>
<td>894.13 49.71</td>
<td>1798.71 100.00</td>
</tr>
<tr>
<td>Change</td>
<td>99.97 3.2</td>
<td>-9.8 -3.2</td>
<td></td>
</tr>
</tbody>
</table>
From looking at (Figure 9) and (Table 6) we can see that the private land which is classified as woodlot in 2006, whether it changed to woodlot or remained woodlot from 1988, covers 47.35% of the land. The patterns which have occurred in the changes from other land use to woodlot in Study Area 2 are mainly situated in the northeastern portion of the study area around the public settlement of Mt. Blanchard. The reasoning for this could be the development of the urban public area leading to less agricultural practices occurring in the surrounding region. As the disturbance of agriculture and farming is removed from these open spaces, the process of succession has developed an increased amount of woodlot land area around this public settlement.

As Hancock County is situated in the northwestern portion of Ohio where the land is more suited for agricultural production and the growing of crops, the returning of woodlots can be predicted to be less prominent than other counties in Ohio. In Study Area 1, the approximate percent change of woodlot to other land use was approximately 4.5%; while this percent change in Study Area 2 is approximately 6.4%, however, the location of the loss of woodlots in Study Area 2 is located in agricultural areas rather than along the river bed in Study Area 1 which was associated

<table>
<thead>
<tr>
<th>Classification of Private Land</th>
<th>Area (Hectares)</th>
<th>Percent of Private Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Land - Woodlot in 1988 - Woodlot in 2006</td>
<td>680.87</td>
<td>36.23</td>
</tr>
<tr>
<td>Private Land - Woodlot in 1988 - Not Woodlot in 2006</td>
<td>120.26</td>
<td>6.40</td>
</tr>
<tr>
<td>Private Land - Not Woodlot in 1988 - Not Woodlot in 2006</td>
<td>869.21</td>
<td>46.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1879.27</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>
with classification differences between the two datasets. By visually looking at (Figure 9) there are clear blocks of woodlots which have changed to other land use from 1988 to 2006. The explanation for this can only be linked to the suitability of the land for agriculture and the location next to existing farmland. Farmers in these areas may have been expanding their production or adding new yields to their output, therefore needing more land.

The other small changes which have occurred in Study Area 2 which are scattered throughout the area could again be due to problems with classification differences between the two datasets. The small individual location of these changes can only be explained from the differences in DOQ images and LIDAR as sources for the data. With the poor quality of the black and white DOQ images, the detection of these small areas of woodlots could have easily been missed during the classification process.

**Comparisons between Study Area 1 and 2**

There are clear comparisons that can be made between study areas 1 and 2 in the land cover results. The area covered by the land use of ‘Woodlot’ increased in both study areas by a similar amount between 1988 and 2006. The ‘Woodlot’ class in study area 1 increased by 3.73% (92.93 Hectares) whilst the increase of this class was 3.2% (99.97 Hectares) in study area 2. Looking at the two study areas combined, the land cover transition tables below show the changes of land cover within both study areas (Tables 7 and 8).
From (Tables 7 and 8) the results show that there is a decrease in the percentage of land classed as ‘Other Land Use’ and an increase in land classed as ‘Woodlot’. There is also a greater change from ‘Other Land Use’ to ‘Woodlot’ than there is from ‘Woodlot’ to ‘Other Land Use’ from 1988 to 2006, showing that there is a general trend of increasing woodlots returning to Hancock County in Ohio.

**Conclusions**

From the results, it is clear that the trend of increasing private woodlot land since the turn on the 20th century is continuing within Ohio. The land cover classified by woodlot, increased by 3.73% and 3.2% in Study Area 1 and 2 respectively and the percentage of private land changing
from other land use to woodlot between 1988 and 2006 was 10.49% for study area 1 and 11.12% for study area 2.

This change over the recent decades is a positive factor to local ecosystems and wildlife as well as the crop yield itself. With an approximately 10% increase in both Study Area 1 and 2, the benefits of an increasing amount of woodlot with good management can secure, improve and diversify wildlife habitat while keeping the woodlot healthy and productive. Other benefits of woodlots are their role as reservoirs of biodiversity, carbon sinks, a resource for fuelwood and a source of clean water, since they are often the only forest in inhabited rural areas. What is interesting is how woodlots, serving as windbreaks and shelter belts, help increase crop yields, reduce fuel consumption and promote soil conservation. Therefore, the change of previous agriculture land to woodlot can actually serve as a benefit to the remaining land used for farming.

Finally, with an american society which has slowly moved away from heavy agriculture and industry in the past century onto an economy ran by the tertiary sector, the reliance on the land for open space has decreased. The recent increase in Ohio's forest land is due primarily to the reversion of abandoned pasture to brush and ultimately mature forested areas. Due to the process of succession, many woodlots are now returning, however with the involvement of humans, the total percentage of land forested will never come close to returning to the amount present prior to early settlers.
References


Digital Orthophoto Quadrangle (DOQs). USGS. Retrieved April 15, 2016, from https://lta.cr.usgs.gov/DOQs


