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Changes in Forest Cover Within and Around Moxie Woods, PA: 1939-2015

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Abstract

Informed forest management is best practiced when there is a strong understanding of prior land use practices that influenced current forest composition and forest ecosystem processes. Quantifying influences of historical land uses helps to predict future forest vegetation and productivity. This study examined changes in land use and land cover (LULC) within and around the 128-acre Moxie Woods Reserve, a sustainably-managed forest located in northwestern Pennsylvania that is owned by the Foundation for Sustainable Forests (FSF), an organization that seeks to sustainably manage and harvest forests. Examining aerial photographs from 1938, 1968, and 2015, we used geographic information system (GIS) technology to analyze LULC changes over time in a 2990 acre area surrounding of Moxie Woods. We found that over a nearly eight decade period, this region experienced a dramatic shift from a predominantly agricultural landscape to an increasingly forested landscape. Agriculture comprised 80% of the land use in the region in 1939, declining to 31% in 2015. The decline was particularly dramatic at Moxie Woods, where agriculture declined from 91% to 0% over that same time interval. In contrast, forested land in the region increased from less than 1% in 1938 to 46% in 2015, and from 0% to 72% at Moxie Woods. The Moxie Woods property has transitioned from predominantly agricultural land to a heavily forested enclave in a region where much of the landscape is still under active agricultural use. Because of the similarity in historical land use between Moxie Woods and the surrounding region, Moxie Woods can serve as a model for sustainable forestry approaches on former agricultural lands that are reverting to forested cover.

Introduction

Before European settlement in 1630, the area of forest land cover over the portion of North America that would eventually comprise the United States was approximately 423 million hectares, or 46% of the total land area (USDA Forest Service, 2001). By 1907, deforestation associated with anthropogenic activities, including subsistence and commercial agriculture, building and railway construction, and domestic fuel, reduced forest cover to an estimated 307 million hectares, or 34% of the total land area in the US. As the demand for forest resources and agricultural land decreased in response to industrialization and advances in mechanization and agricultural practices, agricultural lands began to revert to forest ecosystems (MacCleery1993). Presently in the United States, forests occupy about 70% of the total area that was forested prior to European settlement (MacCleery 1993).

Prior to European colonization, forests dominated the land that would later become Pennsylvania (PA), covering more than 90% of the landscape (Whitney and DeCant 2003). However, more than 60% of Pennsylvania's forests were lost by 1900 as a result of land being cleared for agricultural use and natural resource extraction. Increased conservation efforts, reduced use of wood as a fuel source, and westward migration led Pennsylvania's forests to begin recovering in the early 20th century; today, about 60% of Pennsylvania is covered in forests (PA DCNR 2010).

Despite the many benefits of the return of forests, the history of prior land remains evident in redeveloping forests (Koerner et al. 1999, Patru-Stupariu et al. 2013). For example, the land surfaces of previously plowed forest sites are typically flat and homogenized, soil nutrients and stores of organic matter can be drastically reduced, and forest vegetation heterogeneity and production may be lowered (Fraterrigo et al. 2005, Hermy and Verheyen 2007).

Past land activities affect current forest composition and influence future forest dynamics (Foster et al. 2004). Knowledge of historical activities can help guide forest management practices for forests with similar land use histories. Hence, sound forest management requires an understanding of prior land use. The Foundation for Sustainable Forests (FSF) seeks to sustainably harvest and manage forests in the region, including northwestern Pennsylvania, western New York, and northeastern Ohio. Recently, the foundation acquired a 128-acre, parcel of forested land in northwestern PA and is conducting harvest and management activities to advance long-

term forest sustainability and to provide an example of sustainable approaches that can be used by forest landowners in the area. To help guide forest management plans and to assess the utility of this parcel as a model for sustainable forestry, this study quantifies land use at Moxie Woods in land immediately adjacent to Moxie Woods.

Methods

Moxie Woods, located in Otter Creek Township, Mercer County, PA, is a 128-acre forested parcel that has been permanently protected by the Foundation for Sustainable Forests through a charitable bargain sale. The forest has been protected since 1970, when the Moxie Cooperative Community purchased the land for small-scale agriculture. However, little of the land on the property was used for agriculture since that purchase, and the land subsequently reverted to forest. Under the stewardship of the FSF, the land will undergo active, sustainable forest management.

All map resources used in this analysis were publically available online. Black and white aerial photography of the study region for the years 1939 and 1968 were obtained from the United States Geological Survey (Price et al. 2017). Full-color satellite images for 2015 were obtained from the National Oceanic and Atmospheric Administration's Geostationary Satellite Server (NOAA 2016). ArcGIS Desktop 10.4 (ESRI 2015) was used to visually interpret and manually digitize LULC at a scale of roughly 1:2,000. To compare land use and land cover (LULC) change in Moxie Woods to the surrounding landscape, we first delineated the boundaries of the Moxie Woods property, and we then established a buffer that extended from the Moxie Woods boundary one mile outwards into the surrounding landscape. Images from 1939 and 1968 were georeferenced in ArcGIS using recognizable landmarks in the 2015 aerial photographs, including road intersections and buildings, as spatial references for unifying the coordinate system.

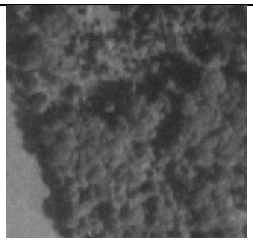
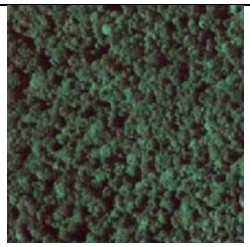
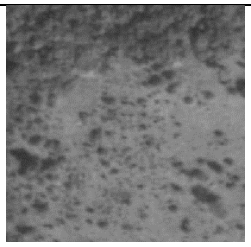
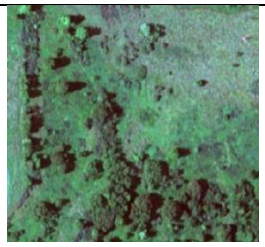
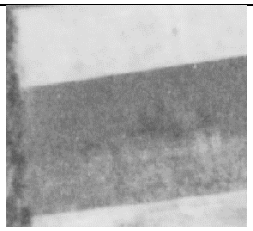
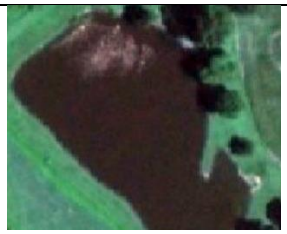
During visual interpretation of the images, and subsequent manual digitization, the LULC was divided into the following categories: dense forest, sparse forest, agriculture, wetlands, open water, and developed (Table 1). These categories are related to categories described in the National Landcover Dataset (U.S. DOI and USGS 2015), are distinguishable by eye on a computer screen, and are important to understand the historical change of land use in the region. Each digitized polygon was categorized as either part of Moxie Woods or in the 1-mile surrounding buffer area.

After the areas were digitized, the total land area classified under each LULC category, within Moxie Woods and in the surrounding area, was calculated.

Results

Over the last 80 years, Moxie Woods and its surrounding area shifted from a landscape dominated by agriculture toward one that is now mostly forested (Figure 1). In 1939, both the region and Moxie Woods were heavily associated with agriculture, but following the decline and abandonment of agriculture in the region, the land began to undergo a succession first to increasing sparse forest seen in 1968 and then to dense forest as seen in 2015. This succession can be easily visualized by focusing on the northern portion of Moxie Woods (Figure 1). In the Moxie Woods region in 1939, agriculture constituted ≈ 80% of the landscape, sparse forest ≈ 17%, and dense forest < 1%, with developed land and water constituting the remainder (Table 2.). Agriculture continued to decline in the area through 1968, and by 2015 agricultural land use declined to 31% in the surrounding area. Conversely, dense forest increased to cover ≈46% of the area, with water and development both increasing slightly during the same time period. Trends at Moxie Woods were similar, although exhibiting an even more pronounced shift from agriculture, which covered 91% of the parcel in 1938, but had declined to 0% by 2015. Simultaneously, dense forest began to reclaim the area, increasing from 0% of land cover in 1938, to 72% in 2015. Together, dense and sparse forest comprised 100% of land cover at Moxie Woods in 2015.

Table 1. Representative samples of land use land cover categories in Moxie Woods region.

	Year		
Land Use/Land Cover	1939 & 1968	2015	Description
Dense Forest			Continuous trees in which few or no gaps were visible between individual trees
Sparse Forest			Contained both trees and visible open spaces
Agriculture			Open spaces that may have been used to grow crops, pasture, or hay and any adjacent farm buildings
Developed Land			Buildings and adjacent green spaces not associated with agriculture
Water			Ponds, lakes, or large water courses

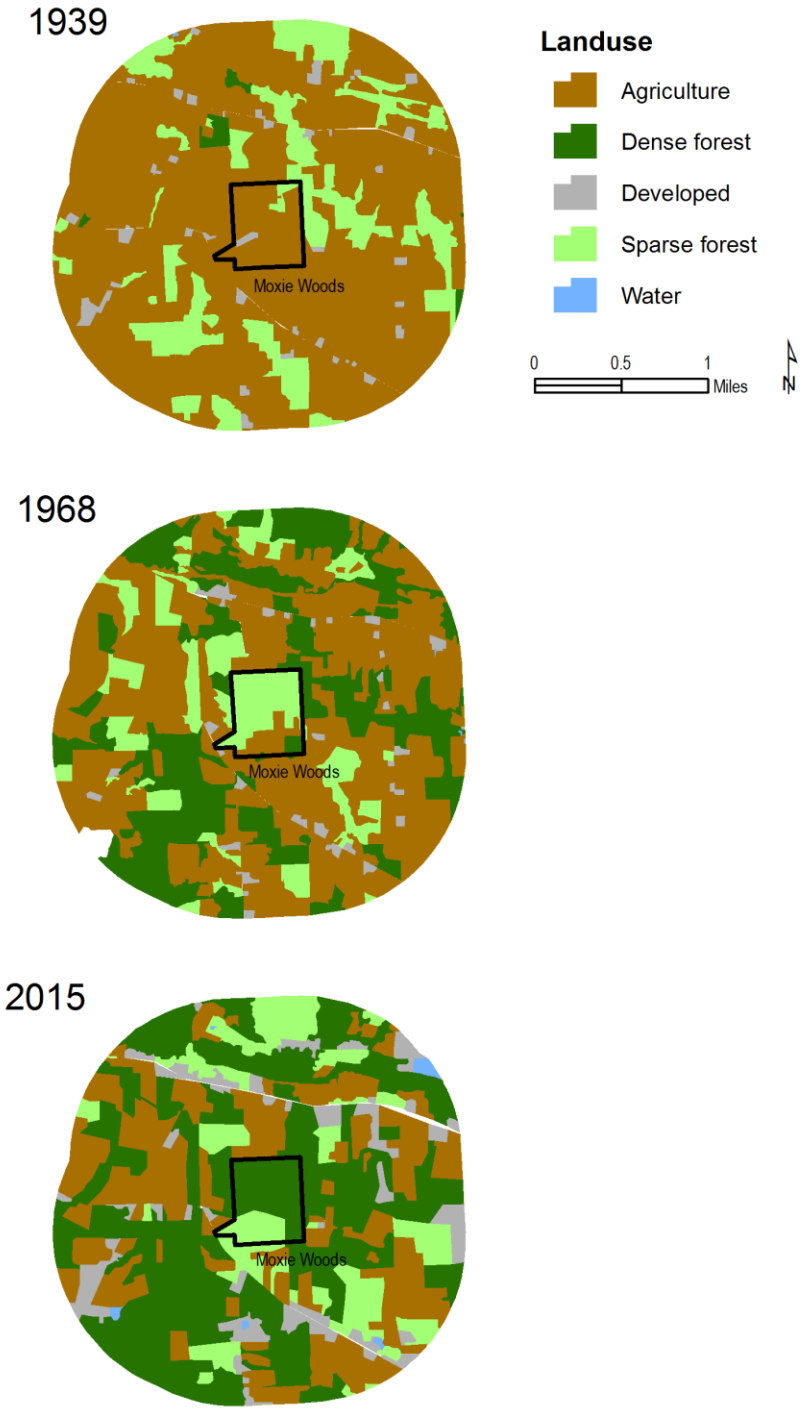


Figure 1. Land Use/Land Cover of Moxie Woods and surrounding area in 1938, 1968, and 2015.

Table 2. Percentage of area in land use categories in Moxie Woods and in the adjoining land in 1939, 1968, and 2015.

	Land Use (%)									
	Agriculture		Dense Forest		Developed		Sparse Forest		Water	
Year	Region	Moxie Woods	Region	Moxie Woods	Region	Moxie Woods	Region	Moxie Woods	Region	Moxie Woods
1939	79.7	91.3	0.9	0.0	2.4	2.5	17.0	6.2	0.0	0.0
1968	56.1	23.3	28.3	6.1	2.1	0.0	13.5	70.6	0.0	0.0
2015	31.0	0.0	46.1	72.2	8.6	0.0	13.8	27.7	0.5	0.0

Discussion

Forest cover in the lands adjacent to Moxie Woods increased dramatically over time. In the 1930s, this area was predominantly used for agriculture, however, increased conservation efforts in Pennsylvania coupled with an employment shift from primarily agricultural to industrial jobs, led to the abandonment of much of the area's agricultural land (Whitney, 1996). This transition encouraged forest re-growth, and by 1968 the region had experienced a dramatic increase in dense forest cover around Moxie Woods and a significant increase in sparse forest cover within the reserve. Continuous agricultural decline, and the 1980 purchase of the 128-acre property by the Moxie Woods Cooperative (Foundation for Sustainable Forests, 2016), resulted in a dramatic increase in forest cover in Moxie Woods. The amount of dense forest cover within the region increased substantially from less than 1% in 1939 to approximately 46% in 2015.

Land use trends in our study match the larger trends in Pennsylvania observed by others. For example, Price and Sprague (2012) found that from 1900 to 1960 in Pennsylvania, forests regrew as farmland was abandoned and as land was increasingly managed for forest uses. Moxie Woods represents an opportunity to demonstrate sustainable forest management on lands that had been formerly used for agriculture, and have subsequently reverted to forest. Much of the regrown forest in this region has already been harvested at least once, however most forest harvest operations are not done in accordance with written forest landowner management plans or in consultation with professional foresters. Without professional guidance, there is a high risk that harvest operations will be executed in an environmentally unsustainable manner, and may thus lead to degradation of forest quality and potential. Moxie Woods itself, although entirely forested,

is recovering from a high-grade forest harvest operation conducted two decades ago that lowered the timber value of the remaining forest, necessitating remedial forest management operations. By conducting sustainable forest harvest and management practices on this property, The Foundation for Sustainable Forests can serve as a valuable reference point in providing long-term value in forests that have reverted from an agricultural past in this region.

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Literature Cited

ESRI. 2017. What is GIS? Web. Retrieved from http://www.esri.com/what-is-gis. Accessed July 2017.

Foster, D, G. Motzkin, J. O'Keefe, E. Boose, D. Orwig, J. Fuller, B. Hall. 2004. The environmental and human history of New England. pp 43-100. IN Forests in Time. Foster, D.R. and J.D. Aber, eds. Yale Univ. Press.

Foundation for Sustainable Forests. 2016. 128 acres protected in Mercer County. Retrieved from http://foundationforsustainableforests.org/new/128-acres-protected-mercer-county. March, 2017.

Fraterrigo, J. M., Turner, M. G., Pearson, S. M., and Dixon, P. 2005. Effects of past land use on spatial heterogeneity of soil nutrients in southern Appalachian forests. Ecological Monographs 75(2): 215-230.

Hermy, M., and Verheyen, K. 2007. Legacies of the past in the present-day forest biodiversity: a review of past land-use effects on forest plant species composition and diversity. Ecological Research 22(3), 361-371.

Jones, S.B., Luloff, A.E., Finley, J.C. 1995. Another look at NIPFs: Facing our myths. Journal of Forestry. 93: 41–44.

Koerner, W., Dambrine, E., Dupouey, J. L., and Benoit, M. 1999. N of forest soil and understory vegetation reflect the former agricultural land use. Oecologia, 121: 421-425.

MacCleery, D. W. 1993. American forests: a history of resiliency and recovery. US Department of Agriculture, Forest Service, FS 540. Durham, North Carolina, USA.

NOAA. 2016. NOAA Geostationary Satellite Server. Retrieved from http://www.goes.noaa.gov/, Accessed February 2017

Patru-Stupariu, I., Angelstam, P., Elbakidze, M., Huzui, A., and Andersson, K. 2013. Using forest history and spatial patterns to identify potential high conservation value forests in Romania. Biodiversity and Conservation, 22(9): 2023-2039.

Pennsylvania Department of Conservation and Natural Resources. 2010. Pennsylvania Statewide Forest Resource Assessment. PA Department of Conservation and Natural Resources, Bureau of Forestry. http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_007864.pdf.

Price, W., and Sprague, E. (2012). Pennsylvania's forests: how they are changing and why we should care. *Pinchot Institute for Conservation*, 1-42.

Price, C.V., Nakagaki, N., Hitt, K.J. & Clawges, R.M. 2017. Enhanced Historical Land-Use and Land-Cover Data Sets of the U.S. Geological Survey. U.S. Department of the Interior, U.S. Geological Survey Data Series 240. Retrieved from https://pubs.usgs.gov/ds/2006/240/, Accessed February, 2017.

U.S. Department of Agriculture Forest Service. 2001. U.S. forest facts and historical trends. Forest Facts Metric 696:1-20.

Whitney, G. 1996. From Coastal Wilderness to Fruited Plain: A History of Environmental Change in Temperate North America from 1500 to the Present. Cambridge University Press, New York, NY. 488p.

Whitney, G., and DeCant, J. (2003). Physical and historical determinants of the pre- and post-settlement forests of northwestern Pennsylvania. Canadian Journal of Forest Research 33: 1683-1697.