Spatial Comparison of Soil Drainage Index to Tree Species in the Central Lower Peninsula of Michigan

David Hon, Kyle Wells, Dr. Christina Hupy

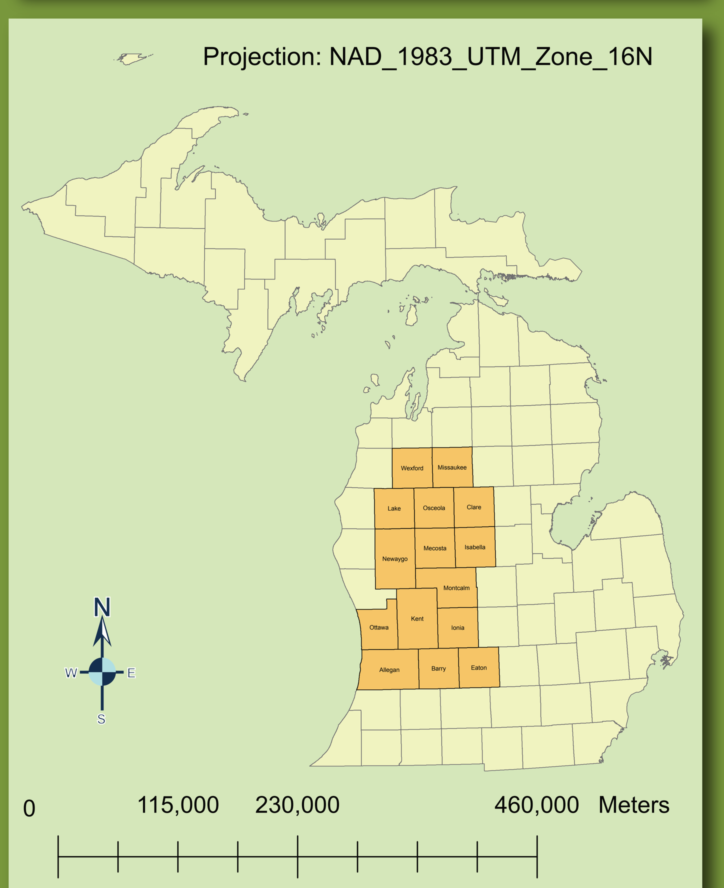
University of Wisconsin - Eau Claire: Department of Geography and Anthropology

Abstract

The purpose of this project is to examine the role of soil moisture in tree species distribution across the forest tension zone, an ecotone between the Laurentian mixed forest and Eastern broadleaf forest in the Lower Peninsula of Michigan. Conservationists, biogeographers and forest ecologists will find the results of this research especially valuable since it describes how tree species are related to long term moisture content in the soil. This project will use the soil drainage index (DI) of each soil polygon, which is an ordinal index based on county level soils data, quantifying long-term soil wetness. The study area within Lower Michigan will be divided into 10 subsections to further detail of the spatial distribution of the tree species. Overlay analysis will be performed within each subsection to associate each tree species with a soil drainage index value. The tabular and graphical data resulting from this project will provide insight into what role soil moisture plays in tree species distribution across an ecotone.

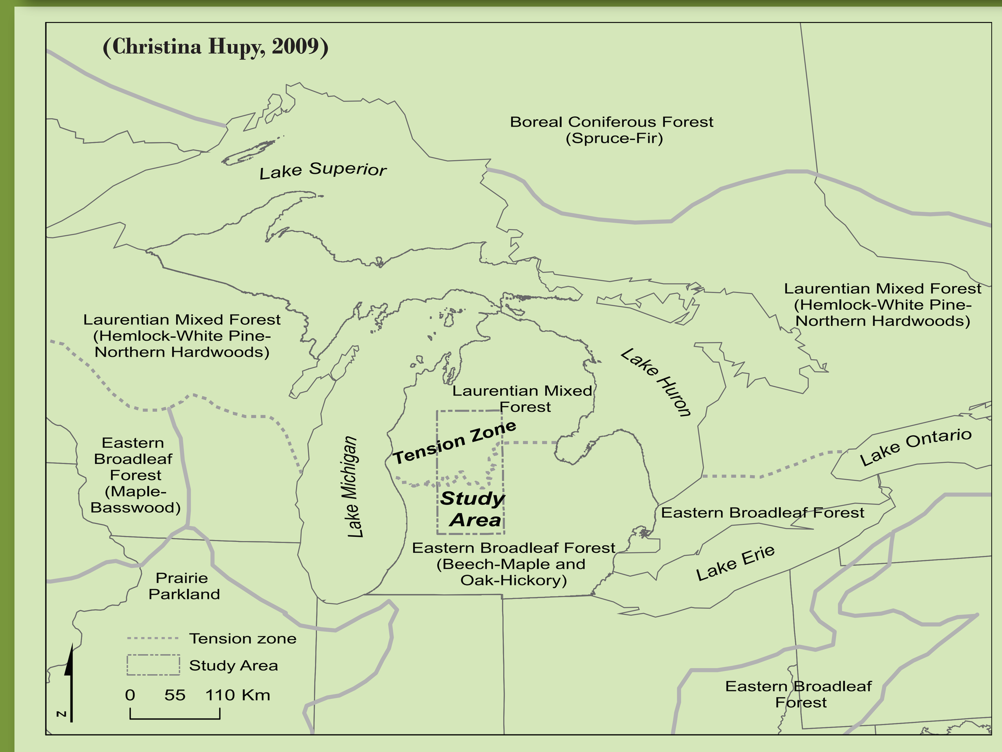
Counties Within the Study Area

There were 15 counties that intersected the study area: Wexford, Missaukee, Lake, Osceola, Clare, Newaygo, Mecosta, Isabella, Ottowa, Kent, Montcalm, Ionia, Allegan, Barry, and Eaton.



Regional Ecological Landscapes and the Tension Zone

The study area, as shown in the image below, is split horizontally by the tension zone, an ecotone between the coniferous Laurentian Mixed forest and deciduous Eastern Broadleaf Forest. The tension zone is an important ecotone because it has a unique and mixed makeup of tree species.



NRCS SSURGO Soils Data and Dr. Randy Schaetzl's Drainage Index

The Drainage Index, developed by Dr. Randall Schaetzl of Michigan State University, is an ordinal index ranging from 0-100 that describes long term soil wetness. We gathered soils data for the 15 counties present in our study area from the Natural Resource Conservation Service's SSURGO website. Notable in the study area is that loamy, fertile soils predominate in the southern portion of the study area, whereas sandy, droughty soils are found mostly in the northern half of the study area.

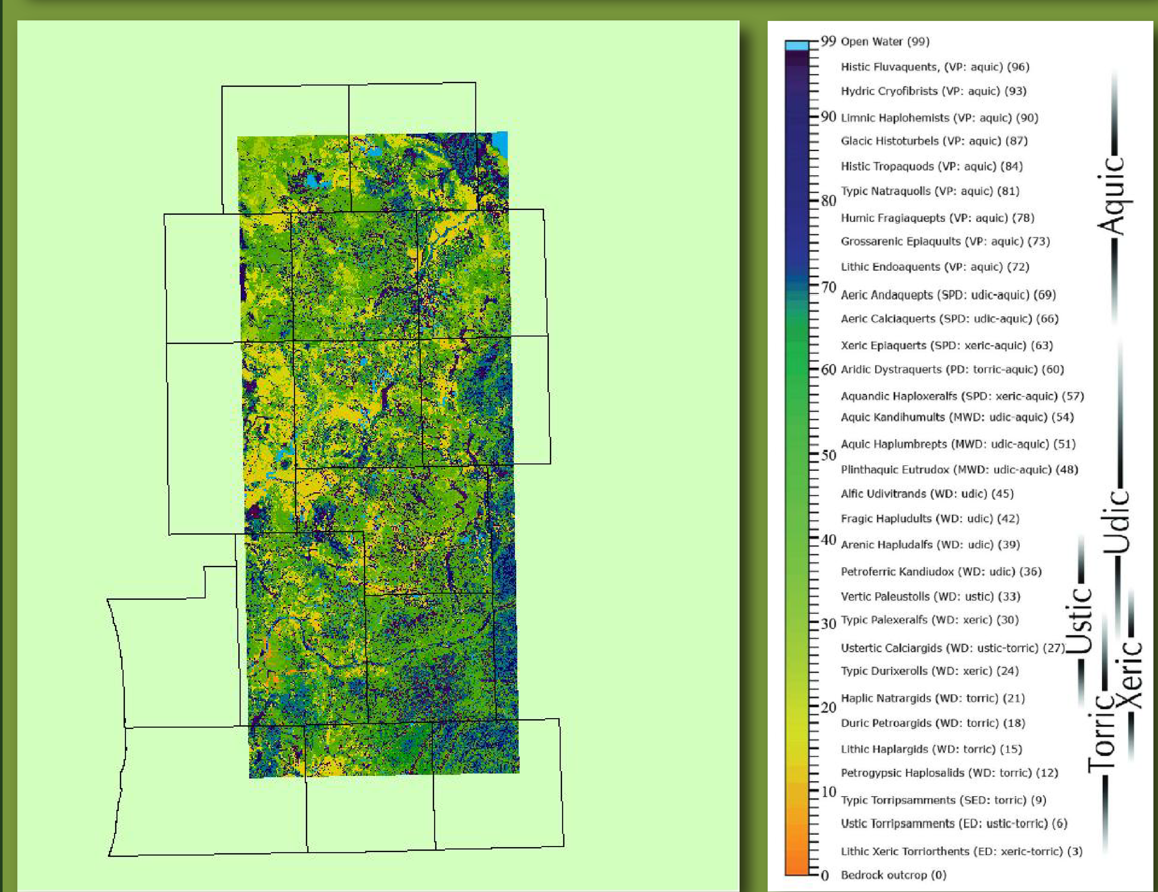


Figure 1: Study Area and Tree Species Distribution

The study area chosen has an area of 12,527 km^2. It was divided into 10 sections with a unique Tension Zone ID to describe the spatial distribution of the tree species present. There were 19,061 trees used in this project: Beech (8,619), Sugar Maple (2,828), White Oak (3,631), and White Pine (3.982).

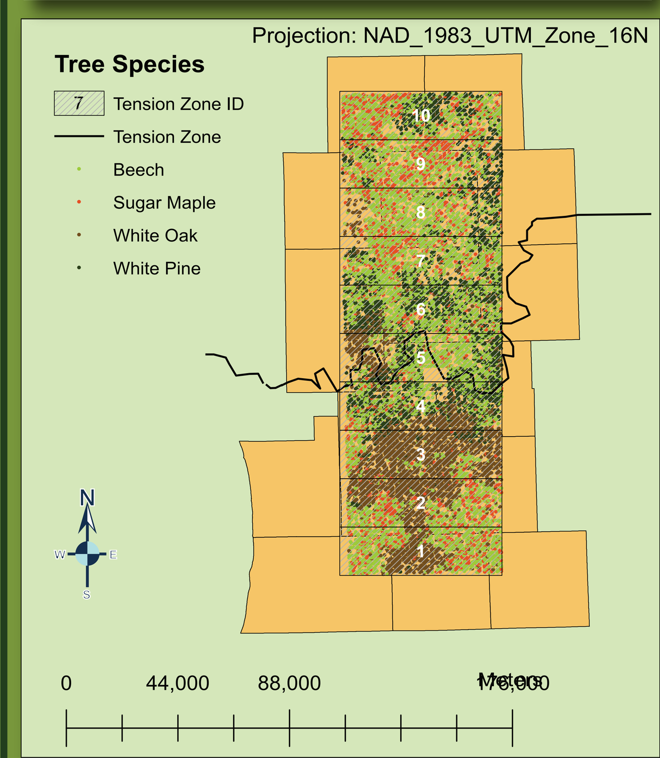


Figure 3: Comparison of Mean Drainage Index Value and Spatial Distribution of White Oak, Sugar Maple, White Pine, and Beech

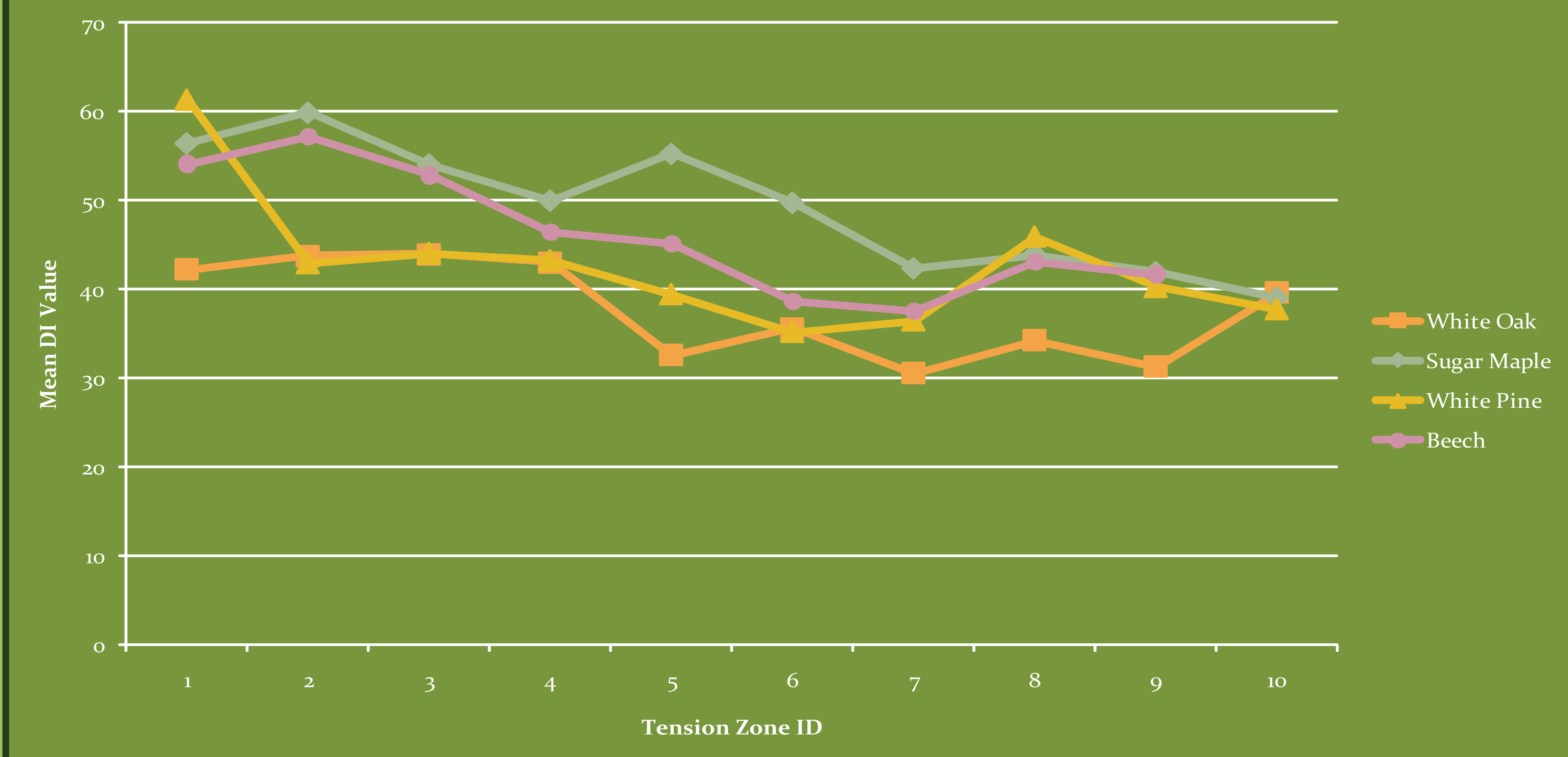


Figure 4: Relative Frequency of Tree Species by Drainage Index Value Range

Methods

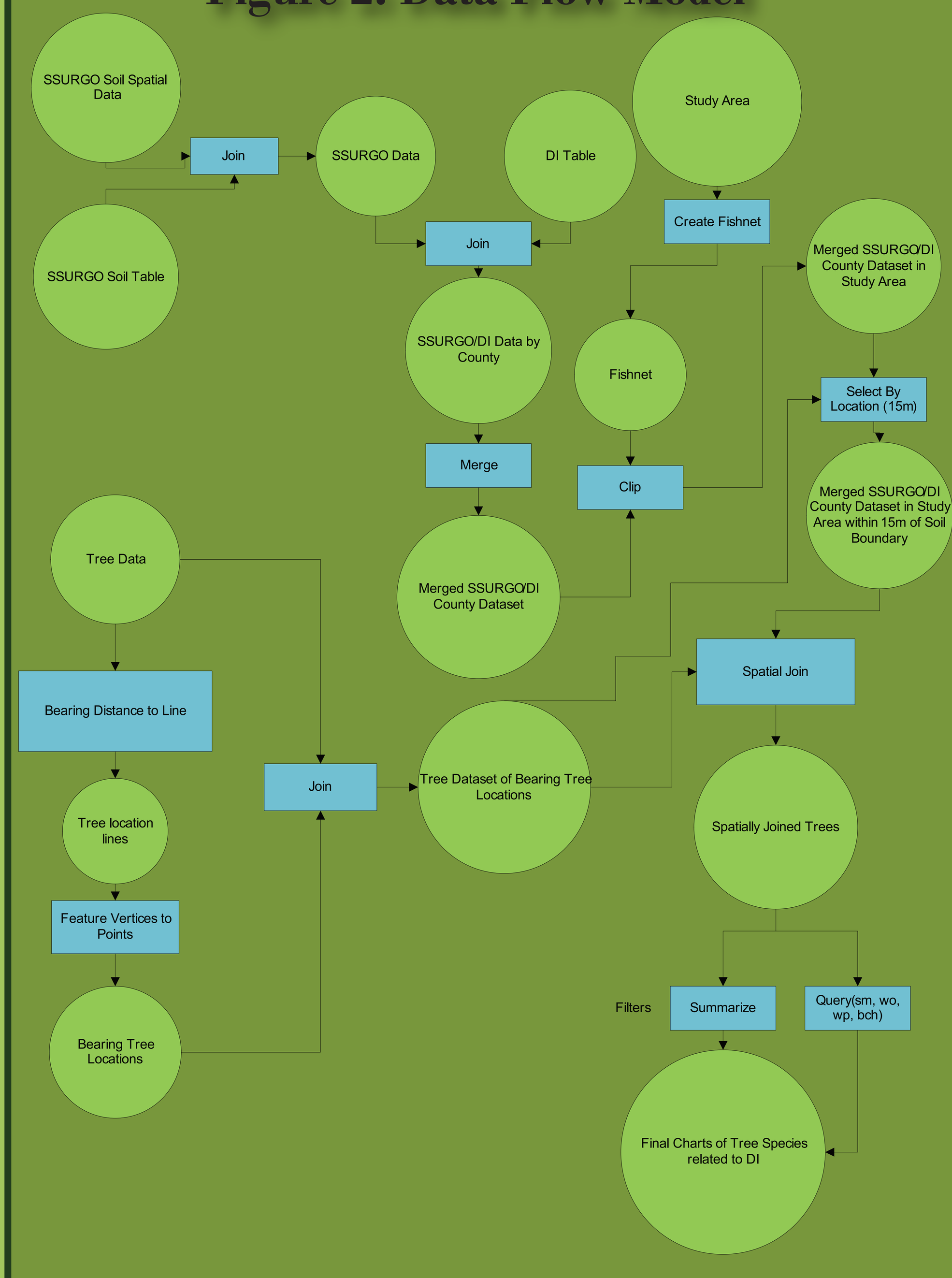
The trees data used was based on historical records from Public Land Surveyors (PLS) in the 19th century. Instead of physically staking out where township and range borders were within the state, the borders were described by the closest large trees by species, distance, and bearing.

The bulk of the time and effort on this project was surprisingly not the analysis, but data processing. A Geographic Information System, ArcGIS 10.0, was used for the majority of this project. The soils data was downloaded from the NRCS SSURGO website and imported using Microsoft Access for each county. Table joins were then made using the component table for each county. A file geodatabase was created. Corrupted trees were then removed from the database through meticulous manual inspection. The trees were then moved in ArcGIS 10.0 based on their bearing and distance to a certain point to their actual location. Trees within 15 meters of a soil polygon were also deleted, leaving roughly 19,000 trees for the analysis.

For analysis, the table was summarized to find mean Drainage Index (DI) value by tension zone, and filters were employed in Microsoft Excel to query tree species by DI range for each tension zone ID.

See Figure 2 for a full visual representation of our methods. Data layers are symbolized by circles and rectangles are symbolized by squares.

Figure 2: Data Flow Model



Data Sources

-Soils data from the Natural Resource Conservation Service's SSURGO website

-Dr. Christina Hupy's bearing tree data from 19th century Public Land Surveyors

-Dr. Randall Schaetzl's drainage index and symbology

-County basemap from the Michigan Center for Geographic Information

Discussion

Upon obtaining the results, the relationship between long-term soil wetness (Drainage Index values) and tree species was unclear. What is clear is that there is a strong inverse relationship between mean Drainage Index (DI) value and tension zone ID. The implication of this is that as latitude increases, the wetness of the soil that all four tree species used in analysis decreased (Figure 3).

Sugar maple is found on the wettest soils, followed respectively by beech, white pine, and white oak (Figure 3).

Worth mentioning is that white oak is found on drier soils than white pine in the southernmost portion of the study area, but on wetter soils than white pine in the northernmost portion of the study area (Figure 3). Also of note is that there appear to be multiple populations of each tree species adapted to wet, medium, and dry soils (Figure 4).

After further review of the geomorphology and physical geography of the area, it is evident that the northern half of the study area is a glacial outwash plain, consisting mainly of coarse-grained, nutrient poor, and excessively drained soils. The southern half of the study area has more rich, loamy soils of morainal origin. Annual precipitation is also a decreasing gradient from the southwest to the northeast of the Michigan. White oak prefers well-drained, warm conditions, so it is present on sandy end moraines in the southern portion of the study area (Figure 1). White pine also enjoys well-drained and coarse-grained soils, but prefers the cooler climactic conditions of the north (Figure 1). Sugar maple and beech are found in valleys and where soil is moist throughout the study area (Figure 1).

Conclusions

1. There are distinct populations of each tree species adapted to different soil wetness conditions, but further investigation is necessary to determine why these tree species have adapted in this way.

2. White oak is clearly found in warm, dry sites, white pine is found in cool sites with well-drained soils, and beech and sugar maple are found throughout the study area where soil wetness is high.

3. The geomorphology of the study area's landscape is a critical factor in determining why the different tree species exist at their current locations. White oak prefers the sandy, warm ridgetops of end moraines, white pine prefers the cool, well-drained outwash plains, whereas beech and sugar maple prefer moist, loamy valley bottoms and low topographic areas.

References

-Hupy, Christina M. and Yansa, C., 2009, Late Holocene vegetation history for the forest tension zone in central lower Michigan, USA.: Physical Geography, v. 30, no. 3, pp. 205-235.
-"Michigan's Floralistic Zones." Michigan State University. Dr. Randall Schaezl, 2008. Web. 2 February 2011.
-Schaetzl, Randall J., Krist, Frank Jr., Stanley, Kristine, and Hupy, Christina M., 2009, The natural soil drainage index: an ordinal estimate of long-term soil wetness: Physical Geography, v. 30, no. 5, pp.383-409.
-Schulte, Lisa A., Mladenoff, David J., Nordheim, Erik V., 2002, Quantitative classification of a historic northern Wisconsin (U.S.A) landscape: mapping forests at regional scales: Canadian Journal of Forest Research, v. 32, no. 9, pp. 1616-1638.
-Hupy, Christina M., A quantitative assessment of the historic forest tension zone in central Lower Michigan, USA.

Acknowledgements

Dr. Christina Hupy for her time, data and invaluable assistance, as well as Dr. Randall Schaetzl for his vast knowledge of soils and his drainage index table and symbology.