Introducing and Applying a Soil Wetness Index Designed for Modeling, GIS and Mapping Applications

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Abstract

We introduce and apply an ordinally based, natural soil drainage index (DI), intended to reflect the long-term amount of useable water that a soil can supply to growing plants under natural conditions. The index ranges from 0 for the very driest soils, e.g., those shallow to bedrock in a desert, to 99, for areas of open water. The DI operates on the assumption that soils in drier climates and with deeper water tables have less useable water; therefore, the soil's natural drainage class and soil moisture regime figure prominently in the calculation of the "base DI." The DI of each taxonomic suborder is available from pull-down menus, and for download, at *www.drainageindex.msu.edu*. In this poster, we present examples of how the DI, when linked to a soil map and our color ramp (see below), can provide insight into landscape wetness patterns. We also provide examples of ecology/forestry applications of the DI.

Introduction

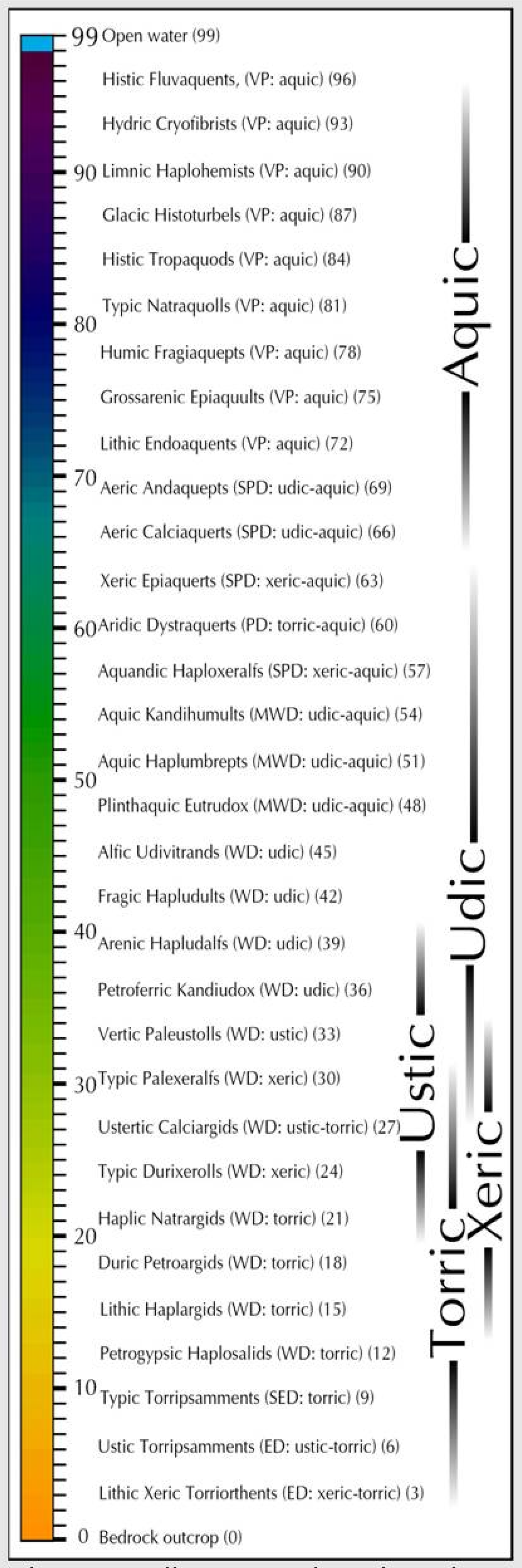
Although soils data are vitally important to many forestry, ecology, GIS and landscape modeling applications, *quantifying* soil-related information is often difficult at the stand or landscape scale. Especially difficult to quantify is *long-term* soil water content, or wetness. In our approach, we argue that soil wetness (on long timescales) can be reasonably estimated by incorporating data that are contained within the soil's classification, e.g., drainage class, texture, depth to bedrock, etc. In this paper we present an ordinally based, natural soil drainage index (DI), intended to generally reflect the amount of water that a soil can supply to growing plants under natural conditions. Soil moisture regime and natural drainage class figure prominently in the "base" DI formulation, which is then modified by additional factors that can impact soil water content and/or quality.

Methods

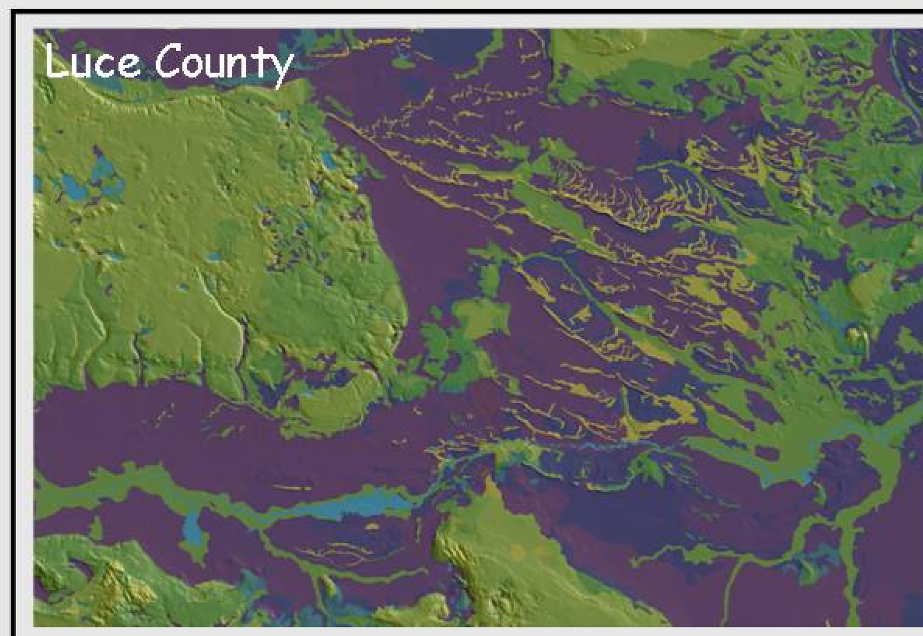
Part 1. Soil landscape wetness pattern visualization. SSURGO (county-level) soils data for Michigan were joined with the DI table (accessible at www.drainageindex.msu.edu) in ArcMap. Our color style ramp was then used as symbology. We adjusted the soils layer transparency in ArcMap to partially show a hillshade layer below, better illustrating how topography influences drainage, and hence, DI values.

Part 2. Forest health applications. We grouped all DI values into seven wetness, or ecological habitat, categories, designed to mimic classical ecological categorizations (see below). GLO (General Land Office) data on the locations of 48,803 trees in a N-S study area in southern Michigan were then intercepted with a DI-soils map, allowing us to determine the number of GLO witness trees that were found in each of the seven DI "habitat type" classes below. The species frequency values were normalized by dividing the number of trees of a given species in each habitat class by the total number of trees found in that class. This application highlights the ecological utility and general "accuracy" of the DI.

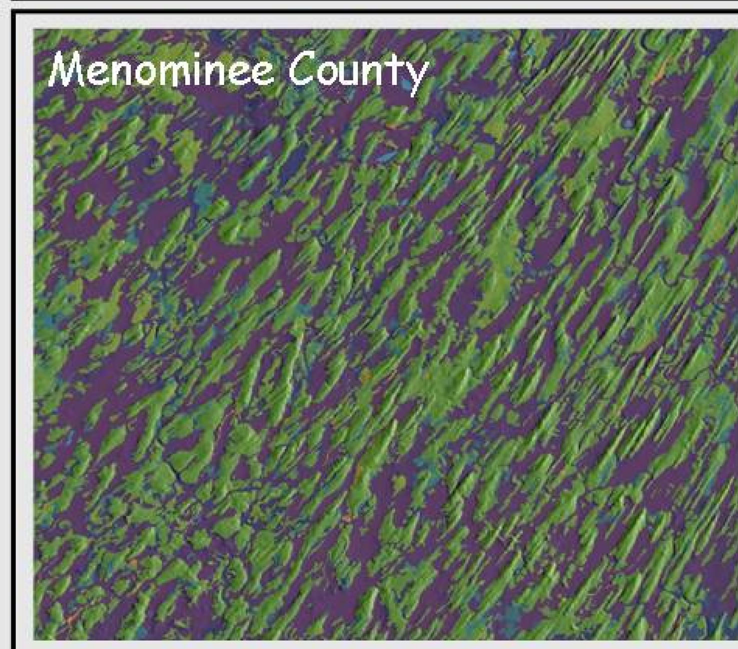
Using the DI to Visualize Soil Landscape Wetness



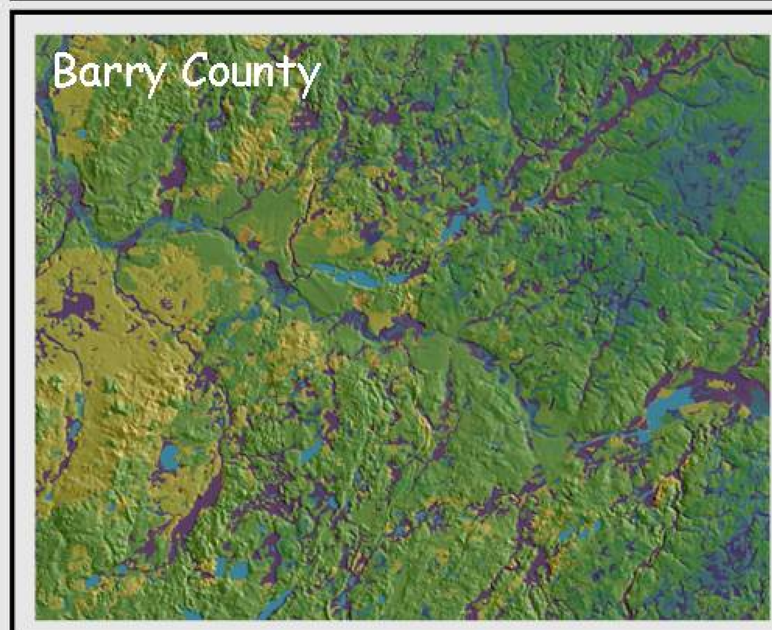
This image illustrates the colors that we have assigned to the various DI values. As the DI value decreases, the colors morph to purples to blues to greens to yellows and finally to orange, designed to mimic soil wetness.



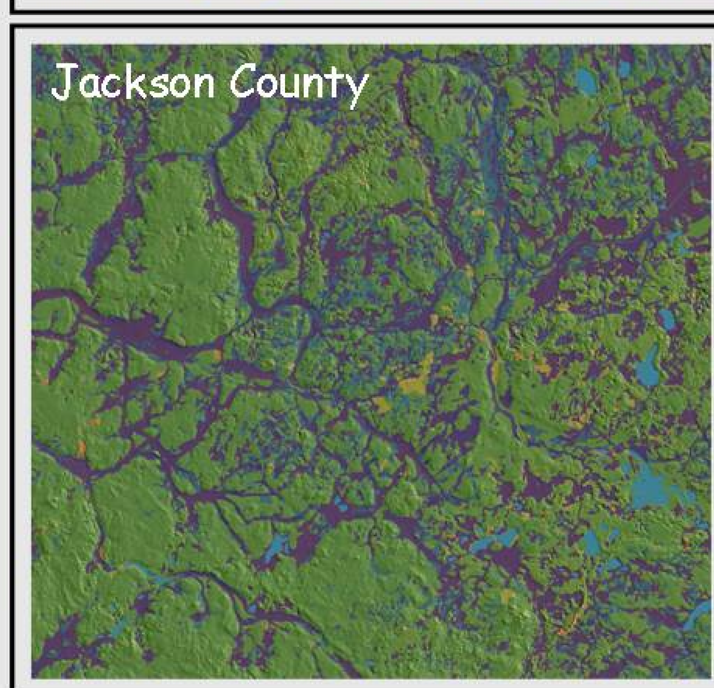
The yellow (DI=19) colors here represent excessively-drained soils on sand dunes in Luce County. These parabolic dunes are well illustrated against the purple background of Lupton, Tawas, and Carbondale mucks of the Algonquin glacial lake plain, with DI values of 91



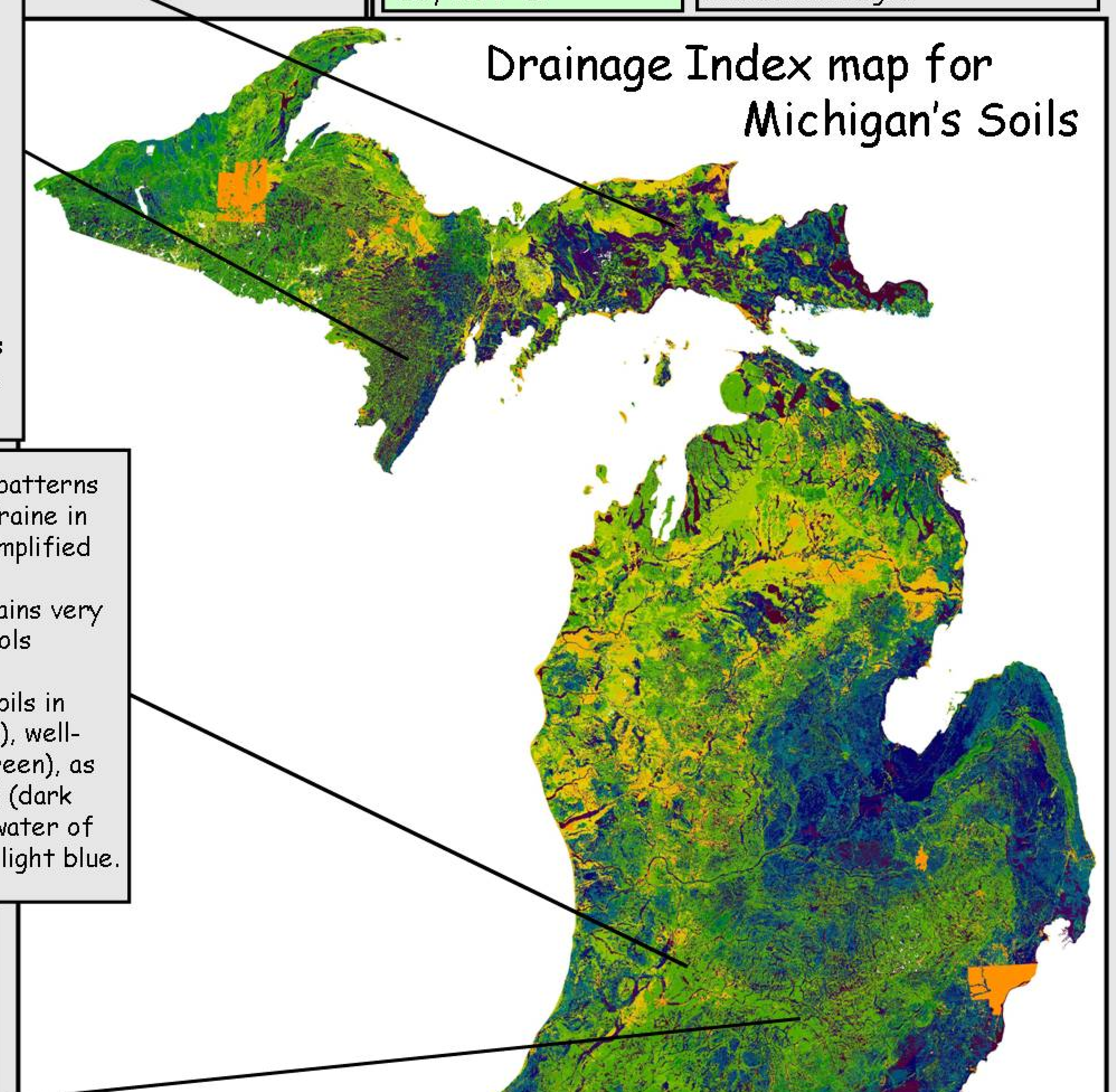
The pattern of wet and dry soils in this area is typical of many drumlin fields. The Menominee drumlin field is comprised of soils formed in well-drained, loamy glacial tills. Well-drained soils on the drumlin uplands are green, while poorly and very poorly drained soils show in blues and purple hues.



The erratic drainage patterns of the interlobate moraine in Barry County are exemplified here. The hummocky topography here contains very poorly-drained Histosols (purple) adjacent to excessively-drained soils in outwash sands (yellow), well-drained soils in till (green), as well as poorly-drained (dark blue) soils. The open water of kettle lakes shows as light blue.

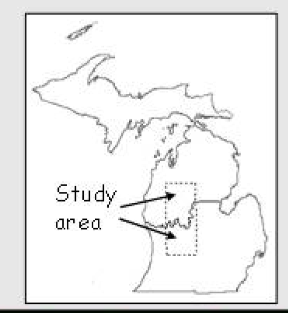


Well-drained soils formed in sandy till, i.e. the Riddles Series, appear green with DI values ranging from 36 to 45. Somewhat poorly-drained, low areas of the landscape appear blue, with DI values between 64 at 70. Poorly and very poorly-drained muck soils appear purple have DIs >88.



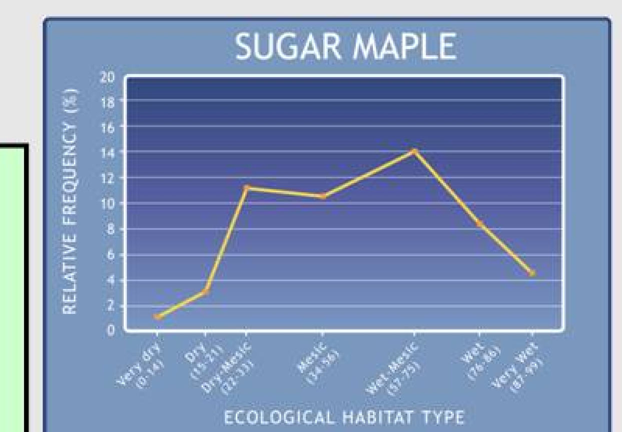
The DI map of Michigan nicely illustrates generalized regions of soil wetness (natural drainage). The blues and dark blues of the Saginaw Lowlands indicate that this region is comprised of mainly somewhat poorly and poorly drained soils of former glacial lakebeds. The yellows across much of northern and eastern Lower Michigan are somewhat excessively and excessively-drained sandy soils formed in dry, glacial outwash. Green areas on the map show dominantly well-drained soils, many of which have formed in loamy till. The poorly-drained soils (purples) of the major river valleys are also readily visible on this map.

Using the DI to Examine the Ecology of Some Tree Species

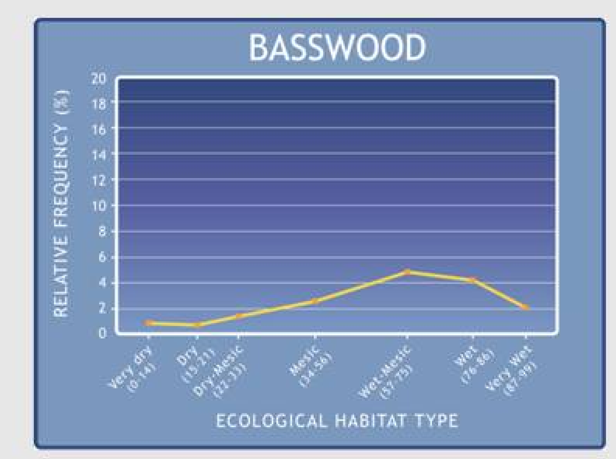


DI values for the ecological habitat/wetness categories used in this study

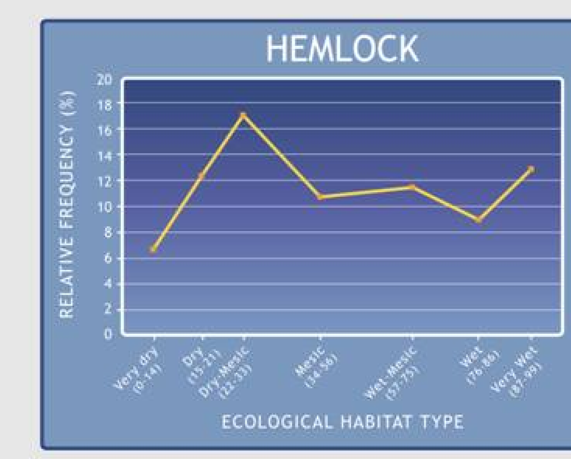
Very dry <14
Dry 15-21
Dry-Mesic 22-33
Mesic 34-56
Wet-Mesic 57-75
Wet 76-86
Very Wet >86



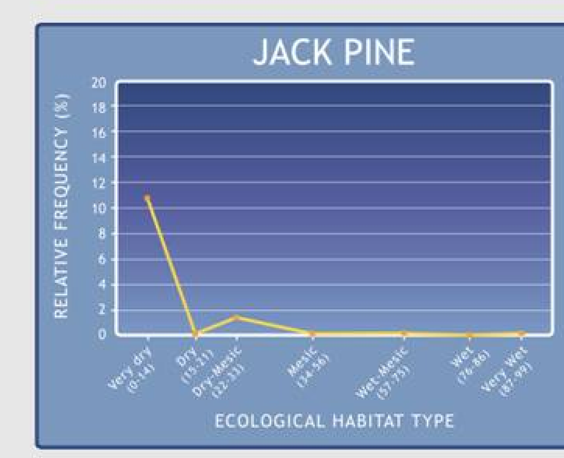
A classic mesic forest species, Sugar Maple was most commonly found on soils with DI values between 22 and 75, in the presettlement forests of southern Michigan.



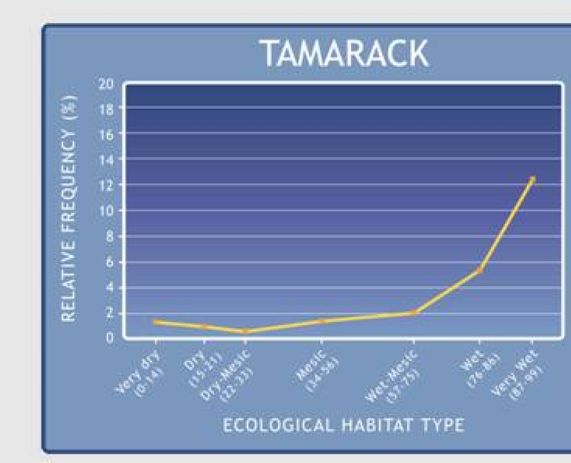
A common Sugar Maple associate, Basswood is, however, commonly found on slightly wetter sites. That relationship is shown clearly on this graph.



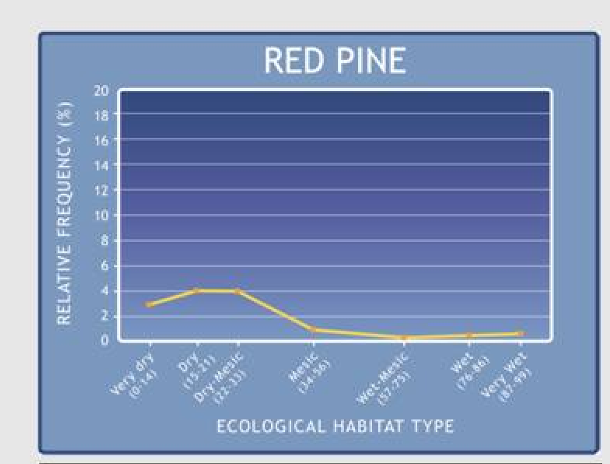
Hemlock, also a mesic forest associate, tends to be more dominant on slightly drier sites, but often in moist microclimatic locations. Our data support this ecological observation, and show that Hemlock is most common on dry-mesic sites with DIs of 22-33.



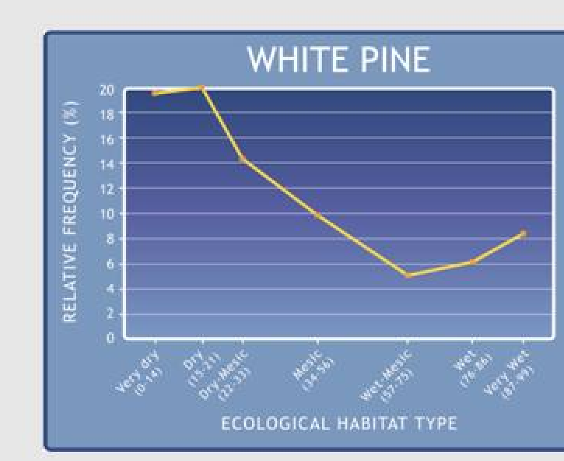
Jack Pine, found today mainly on the very direst sites, was mainly located in presettlement times on soils with DIs <15.



Tamarack (larch) was common on wet sites with DIs >75. These DI values correspond to soils in the poorly- or very poorly-drained classes.



Red Pine is found, today and in presettlement times, on slightly richer and more mesic sites than is Jack Pine. Our GLO data show that Red Pine was not a dominant tree in the presettlement forests, and was most common on soils with DIs <34.



White Pine was a dominant tree on dry sites in presettlement times. It is also frequent on wet sites. This bimodal ecological relationship is captured accurately by the graph above.

Conclusions

In this poster, we provide but a few examples of the utility of the Drainage Index in research and modeling. We urge you to go to the DI web page, download the join file, import it into your GIS database, and explore the potentials of this ordinal index of long-term soil water content. http://www.drainageindex.msu.edu

Acknowledgements

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