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Forest Cover Type and Productivity as Related to Physiography

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Abstract

An analysis of statewide forest inventory data indicates the occurrence of various forest covertypes on the landscape is closely associated with physiographic conditions on those sites. Tables quantifying these relationships are provided as an aid to interpretation of forest inventory data in Minnesota and associated silvicultural opportunities.

Keywords: forest inventory, physiography, cover type

Background

Physiography in forestry refers to the soil and water conditions that affect tree growth on a site. Physiography has long been associated with the growth habit and development of forestland (Bowman 1911). In practice, the classification of stands with respect to physiography has traditionally relied on ground-based observations of hydric soils, drainage, soil texture, tree species, cover type, tree height ~ age relationships, advanced regeneration, and other features associated with specific physiographic classes and forest cover types. Physiographic class data per the USDA Forest Service Forest Inventory and Analysis (FIA) program is also collected on FIA inventory plots nationwide (O'Connell et al. 2017) The current FIA database includes 15 physiographic classes. These classes are described in their full detail in Appendix Table 1.

This classification has also been adapted by the Minnesota Department of Natural Resources (MNDNR) and used in its forest inventory program (MNDNR 2018). The MNDNR has further merged the 15 classes into 5, also described in Appendix Table 1. Given that breakdown, Table 2 shows a tabulation of the 6,290 FIA plots statewide from the 5 year cycle ending in 2017 (Miles 2018) for these 5 classes (actually 7 including two minor "other" classes for completeness here). These classes range from xeric to mesic to hydric and are readily observable in the field.

Results

Given this background, Table 1 shows that Minnesota's forest cover types are closely associated with physiography (physiographic class). Further, there are few surprises. A comparison of the overall distribution of FIA plots shows that 93.3% of the sampled plots fall within the flatwoods (32.4%), rolling uplands (36.5%), or swamps and bogs (24.5%) physiographic classes. The remaining physiographic classes combined contain only 6.3% of the plots. Further, 68% or more of the plots for a given cover type are found on but two physiographic classes. With two exceptions (Lowland Hardwoods and Cotton/Willow), 90% or more of the plots for all other covertypes are found on but three physiographic classes. The vast majority of Black spruce (92.2%), Tamarack (96.8%), and Northern white cedar (80.0%) are found in the swamps and bogs physiographic class. Also, most Oak (91%), Northern Hardwoods (92.6%), Aspen (96.2%), White spruce (91.2%), Balsam fir (69%), White pine (85.4%), Red pine (88.3%), and Jack pine (75.2%) are found in the flatwoods and rolling uplands physiographic classes. Eastern red cedar was found entirely on xeric sites. Finally, Jack pine, White pine, and Red pine also appear on xeric sites.

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Table 1. Tabulation of MNDNR forest cover type occurrence by MNDNR physiographic class as derived from FIA data. Green highlighting indicates percentage of total forest cover. Other percentages sum to 100% for each cover type, with *italics* representing the percentage of each cover type occurring within the physiographic classes. Bold numbers indicate cover type occurrences greater than 10%.

	Physiographic class							
MNDNR Forest Type	**Total**	**Xeric**	**Mesic Flat-woods**	**Mesic Rolling uplands**	**Mesic Other**	**Hydric Flood-plains**	**Hydric Swamps / bogs**	**Hydric Other**
Total	100.0	1.9	**32.4**	**36.5**	2.1	2.5	**24.4**	0.2
Jack pine	2.0	***20.2***	***28.5***	***46.7***	*0.8*	-	*3.8*	-
Red pine	4.1	***11.1***	***36.7***	***51.6***	*0.5*	-	-	-
White pine	1.3	*9.7*	***21.0***	***64.4***	*3.6*	-	*1.3*	-
Balsam fir	3.3	*3.0*	***22.7***	***48.1***	*3.6*	*0.1*	***22.4***	-
White spruce	0.9	*0.9*	***50.6***	***40.6***	*0.3*	*1.7*	*5.9*	-
Black spruce	8.8	*0.6*	*2.4*	*3.5*	*0.7*	*0.3*	***92.2***	*0.3*
Tamarack	6.9	-	*2.1*	*0.9*	-	*0.3*	***96.8***	-
Northern white-cedar	3.6	*0.4*	***10.3***	*5.8*	*2.4*	*0.7*	***80.0***	*0.5*
Eastern redcedar	0.3	***46.7***	*2.2*	***51.0***	-	-	-	-
Oak	9.0	*1.6*	***32.8***	***58.2***	*5.9*	*0.8*	*0.7*	-
Northern Hardwoods	9.1	*0.6*	***24.4***	***68.2***	*5.2*	*0.8*	*0.8*	-
Lowland Hardwoods	8.7	*0.2*	***32.8***	*8.6*	*2.5*	***18.3***	***36.2***	*1.4*
River birch	0.1	-	***22.9***	-	-	***35.2***	***41.9***	-
Cottonwood / willow	0.6	*1.4*	***31.8***	***14.4***	-	***36.5***	***15.0***	*0.8*
Aspen	**30.9**	*0.5*	***55.1***	***41.1***	*0.5*	*0.8*	*2.0*	*0.1*
Paper birch	5.9	*1.6*	***21.9***	***56.7***	*3.8*	*1.3*	***14.8***	-
Other	3.3	*3.8*	***39.3***	***44.9***	*3.9*	*1.8*	*6.4*	-
Nonstocked	1.2	*3.7*	***24.5***	***12.0***	-	*3.8*	***55.9***	-

The remaining physiographic classes shown in Table 1 and elaborated upon in Appendix Table 1 contain little forestland, but likely define areas with unique environmental characteristics affecting tree growth and other vegetative characteristics. Some of these sites could be grouped with the “Swamps/bogs” physiographic class, but are kept separate here to provide a more complete sense of forest cover type distribution among the physiographic classes.

Potential productivity is also closely tied to physiography (Table 2). For example, over 90% of sites with low productivity (SI < 30 feet) are found on hydric physiography (e.g., swamps and bogs). Conversely, almost all better sites (SI > 50 feet) are found on mesic sites. Thus, physiographic conditions appear to play a fundamental role in determining the presence and growth potential of tree species on different sites.

Table 2. Tabulation of FIA plots by MNDNR physiographic class and site index (age 50 years). ***Italics*** **represent the percentage of plots occurring within the physiographic classes by site index group (rows).**

	Physiographic class[1]						
Site index (ft)	**Number of Plots[2]**	**Xeric**	**Other xeric**	**Mesic**	**Other Mesic[3]**	**Hydric**	**Other Hydric[4]**
Total	**6,288**	***1.5***	***0.1***	***68.5***	***4.6***	***25.1***	***0.3***
10 - 20	**113**	-	-	***3.5***	-	***96.5***	-
20 - 30	**447**	***0.7***	***0.2***	***11.2***	***0.4***	***87.9***	***0.2***
30 - 40	**869**	***1.6***	-	***35.6***	***3.5***	***62.9***	***0.2***
40 - 50	**1,428**	***1.6***	***0.1***	***65.5***	***4.6***	***32.6***	***0.6***
50 - 60	**1,659**	***2.2***	***0.1***	***82.9***	***5.8***	***12.1***	***0.2***
60 - 70	**1,449**	***1.1***	***0.2***	***91.4***	***4.8***	***5.0***	***0.1***
70 - 80	**819**	***1.2***	-	***92.7***	***5.6***	***2.4***	-
80 - 90	**196**	***2.6***	-	***93.4***	***4.6***	***1.5***	***0.5***
90+	**45**	-	-	***93.3***	***6.7***	-	-

1 FIA physiographic classes have been condensed for compatibility with designations used by MNDNR.
2 Two plots without site index classifications were omitted.
3 The Other Mesic category corresponds to the hydro-mesic designation used by MNDNR.
4 The Other Hydric is not technically a classification used by MNDNR, but it was retained for consistency in allowing a bin of related, but somehow different sites to be identified for hydric conditions, as is allowed for xeric and mesic, respectively.

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Appendix

Table 1. Comparison of Physiographic classifications by Minnesota Department of Natural Resources[1] (MNDNR) and USDA Forest Inventory and Analysis[2] (FIA).

MNDNR PHYSIOGRAPHY	PHYSIOGRAPHIC CLASS (FIA)	DESCRIPTION (FIA)
XERIC	Dry Tops	Ridge tops with thin rock outcrops and considerable exposure to sun and wind.
XERIC	Dry Slopes	Slopes with thin rock outcrops and considerable exposure to sun and wind. Includes most mountain/steep slopes with a southern or western exposure.
XERIC	Deep Sands	Sites with a deep, sandy surface subject to rapid loss of moisture following precipitation. Typical examples include sand hills, ridges and flats in the South, sites along the beach and shores of lakes and streams.
XERO-MESIC	Other Xeric	All dry physiographic sites not described above.
MESIC	Flatwoods	Flat or fairly level sites outside of flood plains. Excludes deep sands and wet, swampy sites.
MESIC	Rolling Uplands	Hills and gently rolling, undulating terrain and associated small streams. Excludes deep sands, all hydric sites, and streams with associated floodplains.
MESIC	Moist Slopes & Coves	Moist slopes and coves with relatively deep, fertile soils. Often these sites have a northern or eastern exposure and are partially shielded from wind and sun. Includes moist mountain tops and saddles.
MESIC	Narrow Floodplains / Bottomlands	Floodplains and bottomlands less than 1/4 mile in width along rivers and streams. These sites are normally well drained but are subjected to occasional flooding during periods of heavy or extended precipitation. Includes associated levees, benches, etc.
MESIC	Broad Floodplains / Bottomlands	Floodplains and bottomlands 1/4 mile or wider in width along rivers and streams. These sites are normally well drained but are subjected to occasional flooding during periods of heavy or extended precipitation. Includes associated levees, benches, etc.
HYDRO-MESIC	Other Mesic	All moderately moist physiographic sites not described above.
HYDRIC	Swamps/Bogs	Low, wet, flat forested areas usually quite extensive which are flooded for long periods of time except during periods of extreme drought. Excludes cypress ponds and small drains.
HYDRIC	Small Drains	Narrow, stream like, wet strands of forest land often without a well-defined stream channel. These areas are poorly drained or flooded throughout most of the year and drain the adjacent higher ground.
HYDRIC	Bays & Wet Pocosins	Low, wet, boggy sites characterized by peaty or organic soils. May be somewhat dry during periods of extended drought. Examples include sites in the Lake States with lowland swamp conifers.
HYDRIC	Beaver Ponds	
HYDRIC	Cypress Ponds	
HYDRIC	Other hydric	All other hydric physiographic site

[1] See Cooperative Stand Assessment (CSA) used by the MNDNR; the manual is available on the IIC website at http://iic.umn.edu/catalog/land-cover-land-use/detailed-forest-inventory/state.

[2] From FIA Database Description and User Guide for Phase 2 (version: 7.0): O'Connell et al. (2017).