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March 13, 2018

Tom Gapinski
Northern Sands Wisconsin, LLC
923 S. Hastings Way #310
Eau Claire, WI 54701

Thank you for your timely submittal of the benchmark report required by Permit #2015-01.

Our review has found that this submittal is deficient in meeting multiple conditions of Permit #2015-01.

This letter contains the requirements from the Permit (in italics) and bulleted comments for each requirement. Bulleted items in red require follow-up from Northern Sands Wisconsin. All required follow-up reports must be submitted in a Follow-up Report to the Department prior to the start of mining, or at the latest by October 1, 2018, unless otherwise prescribed below.

In addition to this Follow-up Report, Chippewa County will continue to work directly with you to install the remaining monitoring wells that are required prior to mining.

3. Size & Scope

d. An assessment of the existing biological resources at the mine site shall be conducted for each spatial phase of the mine development as depicted in Figure1 of the reclamation plan.

(i) These assessments shall be conducted during the appropriate growing season and a written report of findings shall be filed with the Department before beginning the planned mining activities under each phase of the mine development.

(ii) These assessments shall be conducted using the "Wisconsin Forest Habitat Type Classification System" or an alternative system as approved the Department.

- Written report of findings is included in B. Biological Assessment (existing) – Phase 1 and Appendix A.
- Site was classified using the Wisconsin Forestry Classification System (WFCS). Areas identified include Dry, Dry-Mesic, & Mesic to Wet-Mesic.
    - The assessment shall include documentation of existing trees and assemblages of understory plants using the Wisconsin Forest Habitat Type Classification System/KOTAR Method. See the attached documents for reference.
    - The assessment shall document the methods used for field verification, including when & where the site investigations were conducted and data was collected. Site investigations shall be performed to record the plant species present.

(iii) The biological assessment and field work for Phase 1 of the mine shall commence by October 15, 2016, with a written report of findings to be completed and submitted to the Department by December 31, 2017.

- Report submitted on December 20, 2017.

4. Stream, Stream Corridor & Wetland Protection

a. A baseline hydrologic inventory shall be conducted to define the location of seeps, springs, wetlands, and surface waters located within the permitted mine boundary, and those located on adjacent properties.

(i) This inventory shall be based upon an examination of available resource maps and shall be verified through a general field assessment of the mine site, and adjacent properties if access to the adjacent properties is allowed.

- Inventory was conducted in November, 2017 within Phase 1. 10 seeps and 18 surface water drainages were identified within Phase 1.
    - As part of the inventory, "Surficial Drainage", as identified in C.1 and shown in Appendix C, shall be clarified and mapped using flow lines to depict the areas of concentrated flow and drainageways. Areas of concentrated flow shall be depicted separately than surface waters with stream channel characteristics (continuous bed & banks) for the purpose of establishing riparian buffers (Permit Condition 4.d)
    - As a basis for this hydrologic inventory, include the methodology that was used to determine the existing hydrologic features. Operator may propose that the full baseline hydrologic inventory be conducted in conjunction with other inventories and assessments for individual mining phases, to be conducted in the future, prior to mining a given phase.
    - A baseline inventory was not conducted on neighboring parcels adjacent to Phase 1. This inventory shall be completed and submitted with the Follow-up Report. If the operator does not see value in conducting an inventory of seeps, springs, wetlands, and surface waters on certain parcels adjacent to Phase 1, provide justification utilizing the site specific hydrologic analysis (Permit Condition 4.b).

(ii) This baseline hydrologic inventory shall commence by October 15, 2016, with a written report of findings to be completed and submitted to the Department by December 31, 2017.

- Report submitted on December 20, 2017.

b. A site specific hydrologic analysis shall be conducted by a Professional Hydrologist or Professional Geologist to evaluate and assess the potential for mining operations and reclamation activities to affect naturally occurring seeps, springs, wetlands, and surface waters as documented through the hydrologic inventory required under condition 4.a.

(i) This assessment shall be conducted for each phase of the mine site prior to beginning any mining activities in that mine phase.

(ii) This assessment shall document and describe the source of the water creating the hydrologic condition and shall assess the extent to which these features may be impacted by mining operations and reclamation activities. It shall also specify mitigation measures that can used to reduce any potential impacts to seeps, springs, wetlands, and surface waters.

- Assessment indicates that the identified seeps will not be directly impacted by proposed mining activities. A monitoring well has been installed up gradient of the seeps near the proposed rail area.
- Assessment indicates that subsurface hydrology will be effected both during and post-mining. Restored slopes will generally be less steep than the original slopes.

- Assessment claims that post-mining surface will have similar infiltration to pre-mining surface.
    - Field studies have shown that the post-mining land surface does not regain its infiltration capacity for forested areas.
- Assessment includes multiple mitigation techniques for increasing infiltration post-construction and preserving surface drainage divides.
    - The assessment shall include a sub-watershed delineation of each hydrologic feature (or set of features) in order to determine the water source and the approximate percent contribution from each water source to the feature. The delineation shall be used to assess the extent to which each feature may be impacted by mining operations.
    - The Permit requires a Professional Hydrologist or Professional Geologist to conduct the Site Specific Hydrologic Analysis. Identify the person who has conducted the assessment and their credentials.
    - If certain wetlands will be impacted (filled or hydrologically altered), explain how these activities will be managed to limit the impact to hydrologic features (avoid, minimize, or mitigate).

(iii) The site specific hydrologic assessment and field work for Phase 1 of the mine shall commence by October 15, 2016, with a written report of findings to be completed and submitted to the Department by December 31, 2017.

- Report submitted on December 20, 2017.

d. A continuous riparian corridor and vegetative buffer shall be established to prevent environmental pollution and meet standards for surface water and wetland protection, as established in NR 135.07. The buffer shall be established to be 100 feet from the boundary of wetlands and centerline of watercourses with defined bed and banks. No mining or mine-related activities are permitted within this buffer. Pre-existing agricultural uses including cultivated cropland fields and agricultural pastures shall be allowed within the buffer. The wetland buffer shall be monumented with markers for the life of the mine.

A map of the riparian corridor and vegetative buffers will be prepared to prevent environmental pollution during the life of the mine. Field work shall commence by October 15, 2016, with maps and a report of findings to be completed and submitted to the Department by December 31, 2017.

- A map of the corridors and buffers was produced and included in the report, submitted on December 20, 2017.
    - The mapped buffer does not extend into railyard. Identify how Northern Sands intends to avoid, minimize, or mitigate the impacts to the USGS mapped intermittent stream.
    - The mapped riparian corridors were based on the location of intermittent streams, as shown on the USGS 7.5 minute quad maps, and were not field verified. Watercourses with defined bed & banks must be field verified and submitted to the Department. Riparian corridors and vegetative buffers shall be redrawn based on field verified watercourses with defined bed & banks and wetlands.

f. The Operator shall determine the location of all wetlands within a mine phase using a recognized wetland delineator following procedures established in the 1987 edition of the USACOE Wetlands Delineation Manual.

g. Wetland delineations may be performed over time (in stages), to coincide with the planned phases of mining and reclamation.

h. All wetland delineations shall be completed and a written report submitted to the Department for review prior to beginning mining activities in any phase. The report shall include a map that shows the delineated boundary of the wetlands. The wetland delineation field work for Phase 1 of the mine shall commence by October 15, 2016, with a written report of findings to be completed and submitted to the Department by December 31, 2017.

- A partial wetland delineation was completed in late fall of 2016. This partial delineation identified thirteen wetlands within Phase 1.
    - The partial wetland delineation completed for this report was not conducted during the appropriate growing season. To meet the conditions of Permit Conditions 4.f. through 4.h., the operator shall initiate a state recognized wetland delineation for the entirety of Phase 1 no later than May 1, 2018. This report shall be completed and submitted to the Department no later than August 1, 2018.

11. Site Reclamation & Post-Mining Land Use

e. A freestanding Site Restoration & Vegetative Management Plan shall be developed for each plant community as specified in the reclamation plan. This plan will be implemented by the Operator to guide ongoing efforts to systematically manage, restore, and monitor the property as a management unit. This plan will define management options and recommendations that can be used to enhance the site's ecological and economic value.

(i) This plan shall include a description of the methods that will be used to manage areas disturbed by mining, the methods that will be used to establish and maintain a native prairie and woodlands plantings, and the methods that will be used to control noxious weeds and invasive species.

- Plan includes methodology for installing plantings and controlling noxious weeds/invasive species.

(ii) This plan shall include a minimum of two seed mixes for each plant community that account for varying soil textures and physical site conditions that may range from dry to mesic.

- Plan includes multiple seed mixes for each plant community.

(iii) This plan shall include best management practices for managing prairie and woodland plantings, a timeline showing recommended seeding windows and deadlines, and a multi-year maintenance program.

- Plan includes best management practices, timelines, and an annual maintenance plan.

(iv) The field work required for the development of this plan shall commence by October 15, 2016, and a written plan shall be completed and submitted to the Department by December 31, 2017.

- Report submitted on December 20, 2017.

CHAPTER 12

FOREST HABITAT TYPE CLASSIFICATION SYSTEM

The forest habitat type classification system (FHTCS) is a site classification system based on the floristic composition of plant communities. The system depends on the identification of potential climax associations, repeatable patterns in the composition of the understory vegetation, and differential understory species. It groups land units with similar capacity to produce vegetation. The floristic composition of the plant community is used as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and community development. This classification system enables the recognition of ecologically similar landscape units and vegetation communities. It is a system to classify forest plant communities and the sites on which they develop.

A forest habitat type is an aggregation of sites (units of land) capable of producing similar late-successional (potential climax) forest plant communities. Each recognizable habitat type represents a relatively narrow segment of environmental variation that is characterized by a certain limited potential for vegetation development. Although at any given time, a habitat type can support a variety of disturbance induced (seral) plant communities, the ultimate product of succession is presumed to be a similar climax community. Field identification of a habitat type provides a convenient label (habitat type name) for a given site, and places that site in the context of a larger group of sites that share similar ecological traits.

Individual forest cover types usually encompass a wide range of environmental conditions and do not accurately reflect site potential or respond predictably to given management techniques. In contrast, a habitat type is a group of ecologically similar sites in terms of vegetation potentials. Cover types combined with habitat types can comprise plant community types. Management interpretations can be refined and made significantly more accurate by evaluating a stand in terms of the current cover type (current dominant vegetation) plus the habitat type (potential vegetation).

Forest managers are often charged with the challenging task of assessing site potential and variability when developing management prescriptions and plans for forest stands and properties. The FHTCS provides a tool to improve the process of assessing site potential and evaluating management alternatives. Through application of the FHTCS, land managers are better able to assess site capabilities, identify ecological and silvicultural alternatives, predict the effectiveness of possible silvicultural treatments, evaluate feasible management alternatives, and choose appropriate management objectives.

The forest habitat type classification system serves the following basic functions:

- Management Interpretation -- It enables resource managers to develop long-term management objectives and specific prescriptions for manipulating vegetation based on knowledge of the ecological potential of the land.
- Communication - It provides managers and researchers with a common language for describing forest communities and sites.
- Research - It provides a framework for systematic gathering and interpretation of research data and empirical knowledge.

The Wisconsin Forest Accord is an agreement developed (1994) among agencies, forestry organizations, and conservation groups to provide support for the continued development, evolution, and application of the FHTCS and the National Hierarchical Framework of Ecological Units (NHFEU). It clarifies that these two ecological classification systems share objectives, are complementary, and can work together to achieve better resource communication. The FHTCS facilitates consistent assessment of ecological potentials; it provides a common language for interpreting site capabilities based on potential natural vegetation. The NHFEU divides landscapes into ecologically significant regions at multiple scales and facilitates ecosystem analysis, landscape assessment and planning, and inter-State communication and coordination. The FHTCS provides the vegetative component of the NHFEU in Wisconsin. Development of the Forest Accord has proven valuable in maintaining a consistent approach over time.

Wisconsin FHTCS Resources for System Application and Management Interpretation

- *A Guide to Forest Communities and Habitat Types of Northern Wisconsin*, second edition, 2002, by John Kotar, Joseph A. Kovach, and Timothy L. Burger. Available through the University of Wisconsin-Madison, Department of Forest Ecology and Management.
- *A Guide to Forest Communities and Habitat Types of Central and Southern Wisconsin*, 1996, by John Kotar and Timothy L. Burger. Available through the University of Wisconsin-Madison, Department of Forest Ecology and Management.

- *Analysis of the 1996 Wisconsin Forest Statistics by Habitat Type*, 1999, by John Kotar, Joseph A. Kovach, and Gary Brand, USFS General Technical Report NC-207. Available through the USDA USFS North Central Research Station, St. Paul, Minnesota.
- *Wisconsin Forest Habitat Type Program*, 2004, by Peter Kourtz, John Kotar, Joseph Kovach, and Timothy Burger. Available through the Wisconsin Department of Natural Resources, Division of Forestry, Madison, Wisconsin.

Habitat Type Guides
The two Wisconsin habitat type guides apply to most upland forest sites and communities. Habitat types have not been defined for forested lowlands (poorly drained soils), some southern wet-mesic sites (somewhat poorly drained loams), or for some unusual (of relatively minor extent) forest site types. The guides outline basic concepts and methodologies. They include step-by-step instructions of how to accurately determine habitat types in the field with the use of the keys and tables. Plant identification is a skill critical to successful habitat type identification, therefore photographs and drawings of important understory plants are displayed. The guides include detailed ecological information pertaining to individual habitat types, groups of similar habitat types, and regional associations. Habitat types are described in terms of distribution, landforms and soils, common cover types, development of understory features, disturbance history, successional patterns, and management implications. In addition, the habitat type groups are similarly characterized and general management interpretations are presented. Each of the 11 habitat type regions is characterized individually. These two guides provide the basis for applying and interpreting the forest habitat type classification system in Wisconsin.

Habitat Type Software
The Wisconsin Forest Habitat Type Program provides electronic version of most of the information contained in the two habitat type guides, and a program to identify habitat types based on entered plant lists. The information contained in the two habitat type guides has been synthesized and reorganized to limit repetition and to facilitate presentation and navigation within the electronic format. The plant photo library has been expanded.

The program to identify habitat types depends on individual plant lists that are compiled from relatively homogeneous forested sites. Most major vascular plants must be correctly identified. When accurate plant lists are collected and entered correctly, the program will correctly identify the habitat type about 80-90% of the time, which is similar to the expected accuracy of most well trained field users. The second most likely habitat type is also identified, and the level of confidence in the computerized classification is presented. In application, the program can be utilized to confirm, check, or provide a "second opinion" of field designations. It also can facilitate the relatively rapid collection of large amounts of data by eliminating the need for field identification of habitat types; plant lists can be collected rapidly from many sites and then habitat type designation can proceed electronically. The program can help reduce significant habitat type identification errors associated with system misapplication by untrained users.

This software is available on compact disc, and can be utilized through a disc drive or copied to a hard drive. Instructions (field and computer applications) and documentation are included. This software is not intended to replace the guides; it is intended to augment the classification system in Wisconsin.

Habitat Types and Forestry Inventory and Analysis (FIA)
During the early 1990's most FIA forest land field plots and condition classes were visited to identify habitat types and collect plant species lists. Approximately 5600 plots were evaluated. The FIA analysis publication contains summaries and discussions of major statewide trends and management implications. Various forest attributes are summarized by habitat type. Detailed charts and tables are provided.

Habitat Type Regions
The Wisconsin FHTCS subdivides the state into 11 habitat type regions (5 northern and 6 southern) to facilitate habitat type identification and interpretation (Figures 12.1 and 12.2). In addition, Door County (region 4) and the Baraboo Hills (region 7) are treated as unique subregions. Geographic floristic variation exists and warrants the delineation of region-specific floristic groupings (abstract associations). This approach allows for the construction of more reliable floristic identification keys and more precise descriptions of habitat type characteristics. Regional division is based on climate, geology, soils, physiography, and plant community composition. Because landscape floristic variation tends to be gradational, rather than

abrupt, precise regional boundaries are difficult to determine. For convenience, counties were grouped into regions in such a way that each region can be characterized by at least one major natural feature. However, these regional boundaries are soft, and adjoining regions should be considered when applying the FHTCS near boundaries.

Figure 12.1. Wisconsin's 11 habitat type regions.

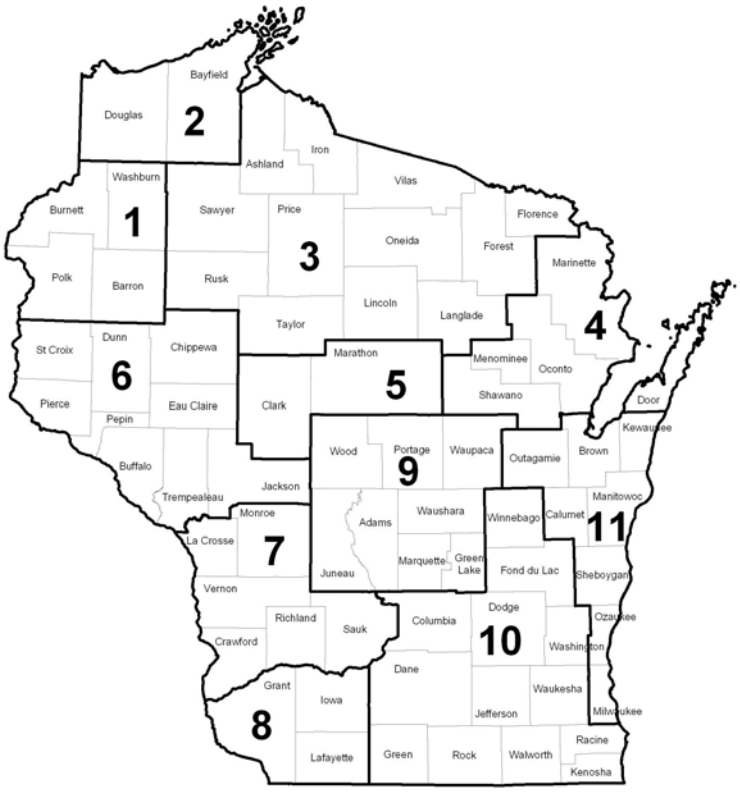
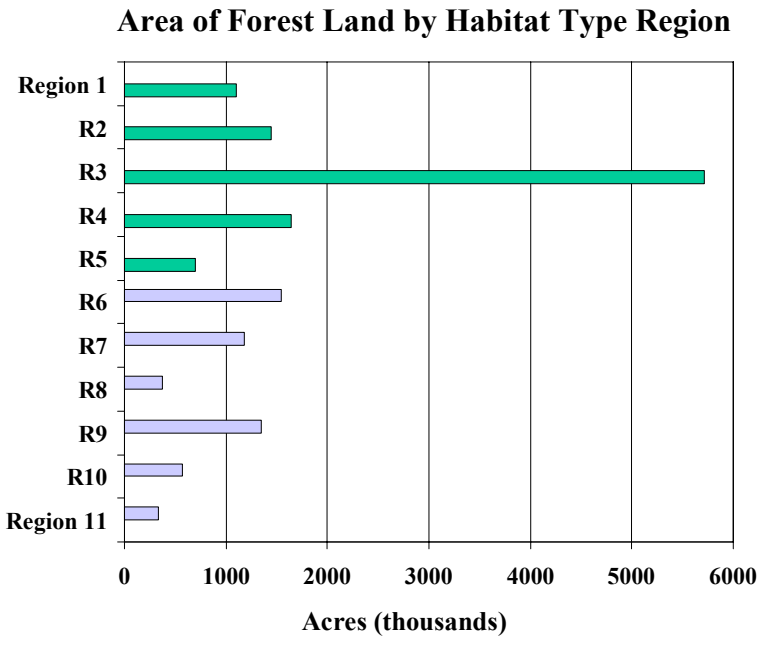


Figure 12.2. Area of forest land by habitat type region based on 1996 FIA.



Habitat Type Naming

Habitat types are named based on species characteristic of the potential climax community type or association. The habitat type name includes the name of the tree species most capable of perpetuating itself in the absence of disturbance, and the name of a characteristic or diagnostic understory species of that site type. An example habitat type name is *Acer saccharum*/*Hydrophyllum virginianum* (Sugar maple/Virginia waterleaf). The first part of the name (preceding the slash) represents the dominant tree species in the potential climax association. The second part of the name (following the slash) represents a characteristic and differential understory species. Sometimes two or three co-dominant climax tree species or two understory species are used in the name, resulting in a lengthy designation. Therefore, for brevity and convenience, abbreviations are normally used. For the preceding example, the abbreviation is AH.

It must be emphasized that habitat types are characterized by specific **plant associations** (definite combinations of species with predictable frequencies of occurrence relative to one another). Habitat types are NOT defined by individual "indicator" species. Casual users of the system often overlook this distinction. This can lead to misidentification of the habitat type and ultimately to mismanagement.

Habitat Type Groups

Habitat types that represent similar positions on the moisture-nutrient gradient can be grouped. Within regions, some habitat types are more similar than others and for convenience can be grouped to discuss similar management interpretations. Between regions, floristically different habitat types can occupy similar positions on the moisture-nutrient gradient and be similar in terms of management implications. These similar habitat types have been organized into six northern groups and eight southern groups. The general position on the moisture-nutrient gradient of the habitat type groups and examples of some of the habitat types that comprise the groups are shown in Figures 12.3, 12.4, and 12.5. Following these three figures is a short description of each of the 14 habitat type groups. The area of forest land represented by each habitat type group and the average growing stock volume per acre that occurred on each group based on 1996 FIA are shown in Figures 12.6 and 12.7. The representation of major tree species across and within northern habitat type groups and their relative growth potentials are shown in Figures 12.8, 12.9, and 12.10; similar representations based on FIA data have not been developed for the southern groups. Tables 12.1 and 12.2 list all delineated habitat types by region and habitat type group.

Figure 12.3. Relationship of habitat type groups to soil moisture and nutrient regimes in the northern and southern regions of Wisconsin. The position of each group is a composite of several individual habitat types. Forest lowlands (wet-mesic to wet habitat type groups 6 and 14) are not included, because habitat types have not been defined.

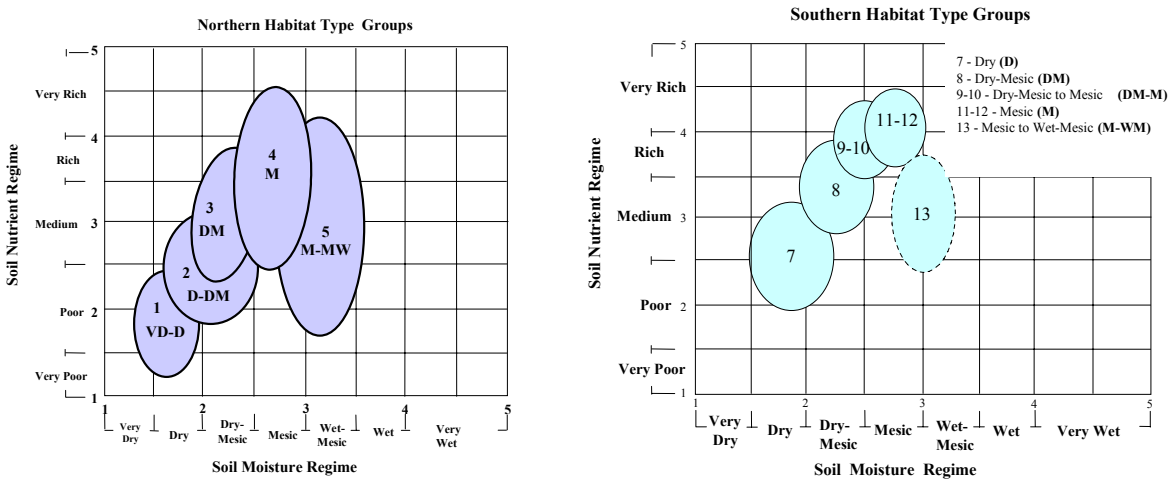


Figure 12.4. Habitat types comprising the northern mesic habitat type group (4), and their relationship to soil moisture and nutrient regimes.

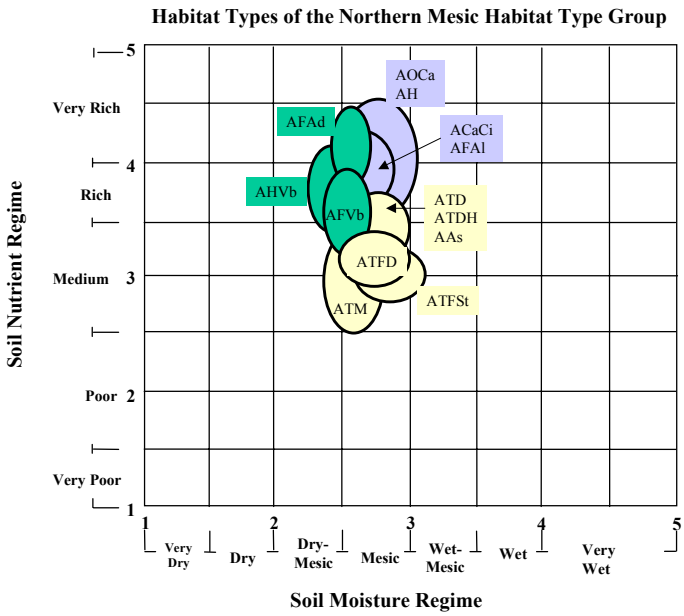
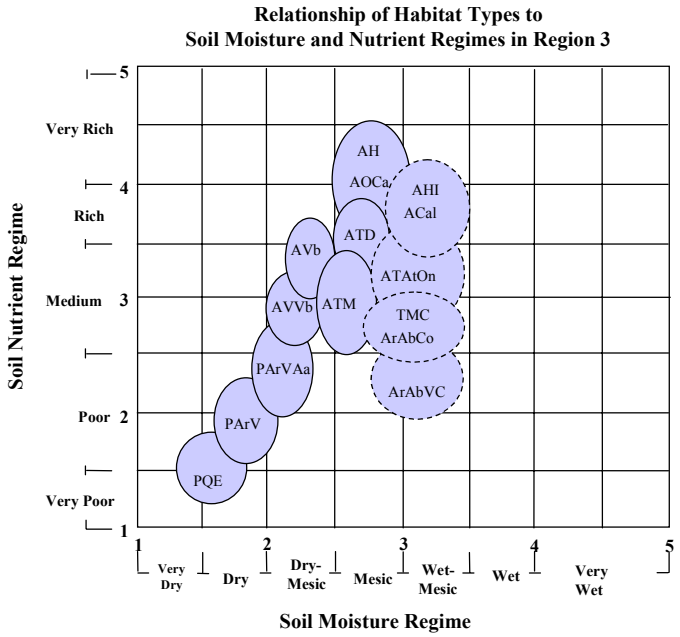


Figure 12.5. Habitat types of Region 3 (part of groups 1-5), and their relationship to soil moisture and nutrient regimes.



A. Northern Habitat Type Groups

1. Very Dry to Dry (VD-D) and nutrient poor
   Habitat Type Series: White pine – Oak, White pine – Red maple
   Habitat Types: PQE, PQG, PQGCe, PArV, PArV-U, PArVAo, QAp
   This group represents the driest and most nutrient poor sites of the northern regions. Forests typically are dominated by pines (primarily jack and red) and poor to fair quality oak and aspen. White pine is sufficiently drought and shade tolerant, that where seed sources exist, it can assert dominance (with red maple and oak) in undisturbed middle to late successional stands. Red maple is the most shade tolerant species found on these sites, however it is intolerant of fire, relatively short lived, and as the sites become droughtier, development becomes poorer.

2. Dry to Dry-mesic (D-DM) and nutrient poor to medium
   Habitat Type Series: White pine – Red maple
   Habitat Types: PArVAm, PArVHa, PArVAa, PArVAa-Vb, PArVAa-Po, PArVPo
   This group is a step up on the soil moisture-nutrient gradient from the preceding group. Forests typically are dominated by some mix of white pine, red pine, aspen, white birch, red oak, and red maple. White and red pine thrive on these types. White pine is sufficiently shade tolerant to reproduce naturally in mixed stands. Red maple is the most shade tolerant species found on these sites, however, compared to white pine, it is relatively short lived, small of stature, and less adapted to fire.

3. Dry-mesic (DM) and nutrient medium
   Habitat Type Series: Sugar maple, Sugar maple – Hemlock – Beech
   Habitat Types: AVVb, AVCl, TFAa, AVDe, AVb-V, ACl, AVb, AAt, ATFPo
   Soil moisture and nutrients are adequate to support shade tolerant, mesic species such as sugar maple, basswood, and white ash, but not at their optimal developmental levels. Following major disturbance (e.g. fire, wind, logging), aspen, white birch, red oak, red maple, or white pine often assume dominance. Without significant disturbance, stands on these types tend to gradually succeed to mesic hardwoods.

4. Mesic (M) and nutrient medium to rich
   Habitat Type Series: Sugar maple, Sugar maple – Hemlock, Sugar maple – Hemlock – Beech,
   Sugar maple – Beech,
   Habitat Types: AFVb, ATM, ATFSt, ATFD, AAs, ATD, ATDH, AHVb, AFAd, AFAl, ACaCi, AOCa, AH
   This group represents the most favorable soil moisture-nutrient conditions in the region. Sugar maple and basswood are the most common dominants. Less shade tolerant species; such as aspen, white birch, red oak, and white pine; can gain temporary dominance only after a major disturbance, especially fire. Other common associates include red maple, white ash, yellow birch, hemlock, fir, and white spruce.

5. Mesic to Wet-mesic (M-WM) and nutrient poor to rich
   Habitat Type Series: White pine – Red maple, Red maple – Balsam fir, Red maple,
   Sugar maple – Hemlock, Sugar maple
   Habitat Types: PArVRh, ArAbVC, ArAbVCo, ArVRp, ArAbSn, ArAbCo, TMC, AAtRp, ASnMi, ATAtOn, ASaI, ACaI, AHI
   This group typically occurs on somewhat poorly drained mineral soils (sands, loams, and clays), and represents a transition from upland to lowland forest. Because of the wide range of nutrient conditions, many species and cover types can occur. Early successional stands dominated by aspen or red maple (and sometimes white birch) currently are most common. In the absence of major disturbance, red maple, balsam fir, and white pine can exert dominance on the more nutrient poor sites, whereas mesic hardwoods (sugar maple, red maple, basswood, ashes, yellow birch) and hemlock can exert dominance on the more nutrient rich sites.

6. Wet-mesic to Wet (WM-W)
   Habitat Type Series: none delineated
   Habitat Types: none delineated
   These are forested lowland sites. No specific habitat types have been delineated. Forests are dominated by swamp conifers (white cedar, balsam fir, black spruce, tamarack) and swamp hardwoods (black ash, red maple, aspen).

B. Southern Habitat Type Groups

7. Dry (D) and nutrient poor to medium
   Habitat Type Series: White pine – Oak, White pine – Red maple
   Habitat Types: PEu, PVGy, PVHa, PVCr, PVG
   These types represent dry, relatively nutrient poor sandy soils, most commonly occurring within and around the central sands region. Pines, oaks, and aspen comprise most stands.

8. Dry-mesic (DM) and nutrient medium to rich
   Habitat Type Series: Red maple, Sugar maple – Red maple, Sugar maple
   Habitat Types: ArDe-V, ArDe, AQVb-Gr, ArCi, ArCi-Ph, AArVb, AArL
   These habitat types represent better growth conditions for oaks and pines. Red maple also competes more strongly, and in the absence of major disturbance (e.g. fire, wind, logging) can assert dominance in late successional stands. Sugar maple does not compete well on these types, and its seed source generally is lacking.

9. Dry-mesic to Mesic (DM-M) and nutrient rich
   Habitat Type Series: Sugar maple – Basswood – White ash
   Habitat Types: ATiFrCi, ATiFrVb, ATiDe-Ha, ATiDe-As, ATiDe, AFrDe, AFrDeO
   Red and white oaks grow well on these habitat types, and make up the largest volume in many present stands. Soil moisture and nutrient levels are adequate to support good growth of mesic hardwoods. In the absence of major disturbance and if seed sources are present, the mesic hardwoods can dominate late successional stands.

10. Dry-mesic to Mesic, Phase [DM-M(P)]
    Habitat Type Series: Sugar maple – Basswood – White ash
    Habitat Types: ATiDe(Pr), ATiFrVb(Cr), AFrDe(Vb), ATiCr(O), ATiCr(As)
    These types represent soil conditions similar to those of the preceding group, but they experienced more frequent fires prior to European settlement. As a result, mesic hardwoods have been virtually eliminated from the landscape, and currently are not replacing oaks or other less tolerant species that dominate current stands.

11. Mesic, Phase [M(P)]
    Habitat Type Series: Sugar maple – Basswood – White ash
    Habitat Types: ATiFrCa(O), ATiAs(De)
    These habitat types occupy soils similar to those of the following group, but they experienced more frequent fires prior to European settlement. As a result, mesic hardwoods have been virtually eliminated from the landscape, and currently are not replacing oaks or other less tolerant species that dominate current stands.

12. Mesic (M) and nutrient rich
    Habitat Type Series: Sugar maple – Basswood – White ash, Sugar maple – Hemlock – Beech,
    Sugar maple – Hemlock, Sugar maple – Beech
    Habitat Types: ATiSa-De, ATiSa, ATTr, AFTD, AFH, ATiFrCa, ATiCa-Al, ATiCa-La, ATiCa, AFAs, AFAs-O, ATiH
    This group represents mesic, nutrient rich sites that experienced relatively little fire disturbance prior to European settlement and continue to be dominated by mesic hardwoods. Management by light partial cutting and passive management favor sugar maple dominance.

13. Mesic to Wet-mesic (M-WM) and nutrient poor to rich
    Habitat Type Series: White pine – Red maple, others not delineated
    Habitat Types: PVRh, others not delineated
    With one exception, specific habitat types have not been delineated. This group typically occurs on somewhat poorly drained mineral soils, and represents a transition from upland to lowland forest. Nutrient regimes can range from relatively poor on damp, sandy soils to relatively rich on damp, silty soils. Currently, stands are most commonly dominated by red maple, ashes, oaks, basswood, and aspen. In the absence of major disturbance, red maple and white pine can exert dominance on the nutrient poor sites, whereas mixed hardwoods can exert dominance on the richer sites.

14. Wet-mesic to Wet (WM-W)

Habitat Type Series: none delineated
Habitat Types: none delineated
These are forested lowland sites. No specific habitat types have been delineated. Forests are dominated by bottomland hardwoods, swamp hardwoods, and swamp conifers.

Figure 12.6. Area of forest land by habitat type group based on 1996 FIA
Approximately 2/3 of Wisconsin's forest land area is associated with northern habitat types, while 1/3 is associated with southern types. Three northern groups; M, M-WM, and WM-W; are predominant, and taken together represent nearly one-half of the total forest land base.

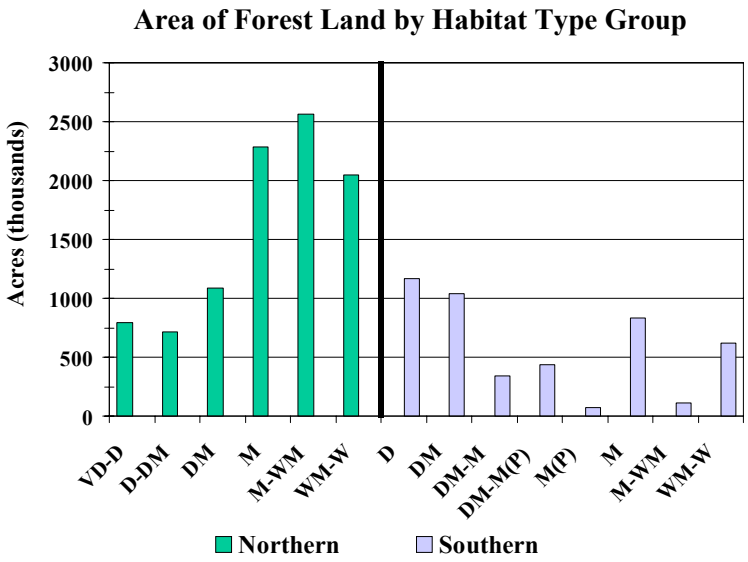


Figure 12.7. Growing stock volume per acre by habitat type group based on 1996 FIA
These volumes reflect the productive capacity of habitat type groups and collective management history. For the northern groups, the trends are reflecting primarily productive capacity. In the south, the effects of management history and pre-European settlement conditions are more evident, particularly in the two phase (P) groups.

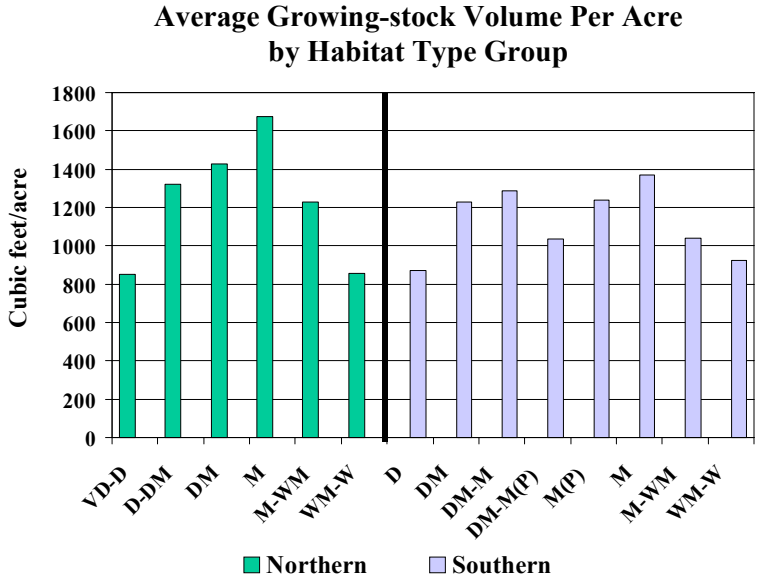


Figure 12.8. Representation of major tree species **across** (read in rows) northern habitat type groups as a percentage of species' total growing stock volume. Based on 1996 FIA. Numbers in parentheses are acres in thousands.

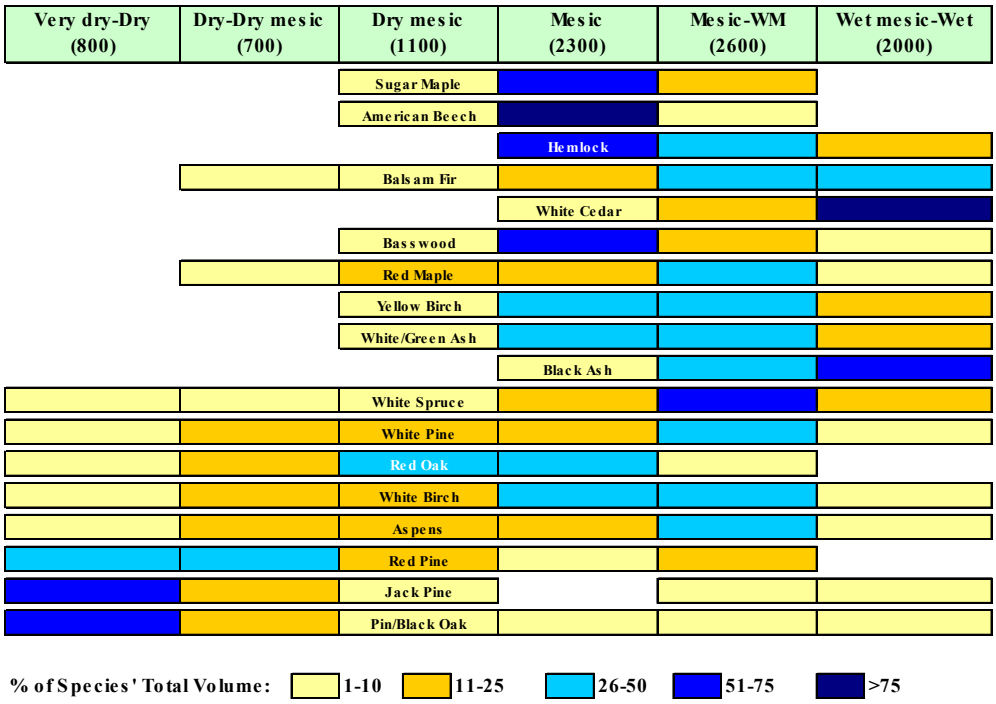


Figure 12.9. Representation of major tree species **within** (read in columns) northern habitat type groups as a percentage of total growing stock volume. Based on 1996 FIA.

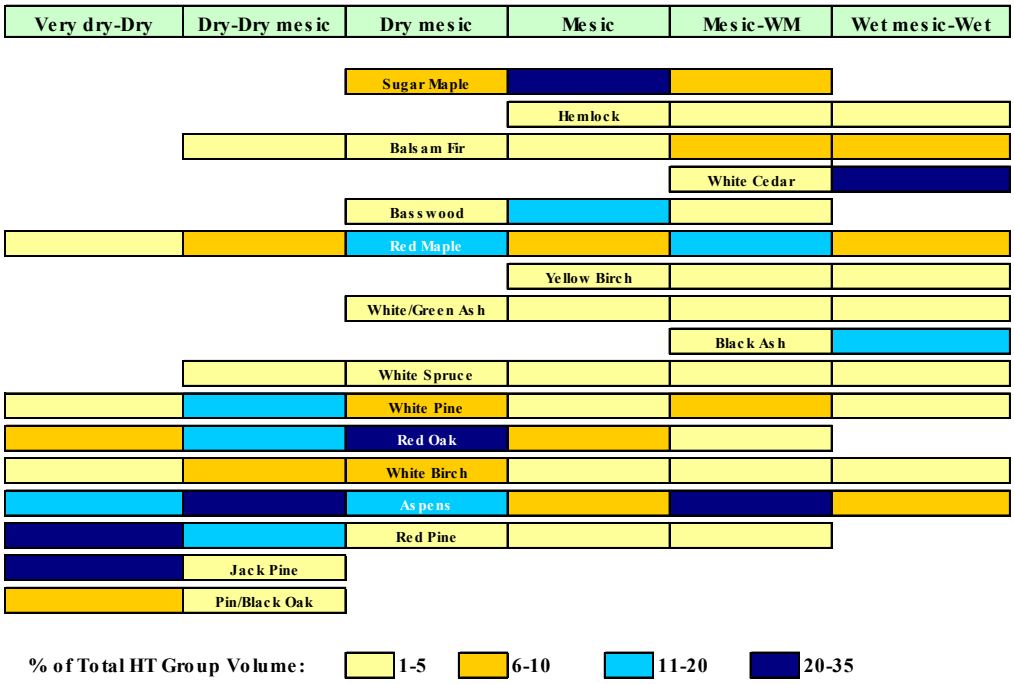


Figure 12.10. Relative growth potential of major tree species across northern habitat type groups. Only those habitat types where the species occurs naturally are considered.

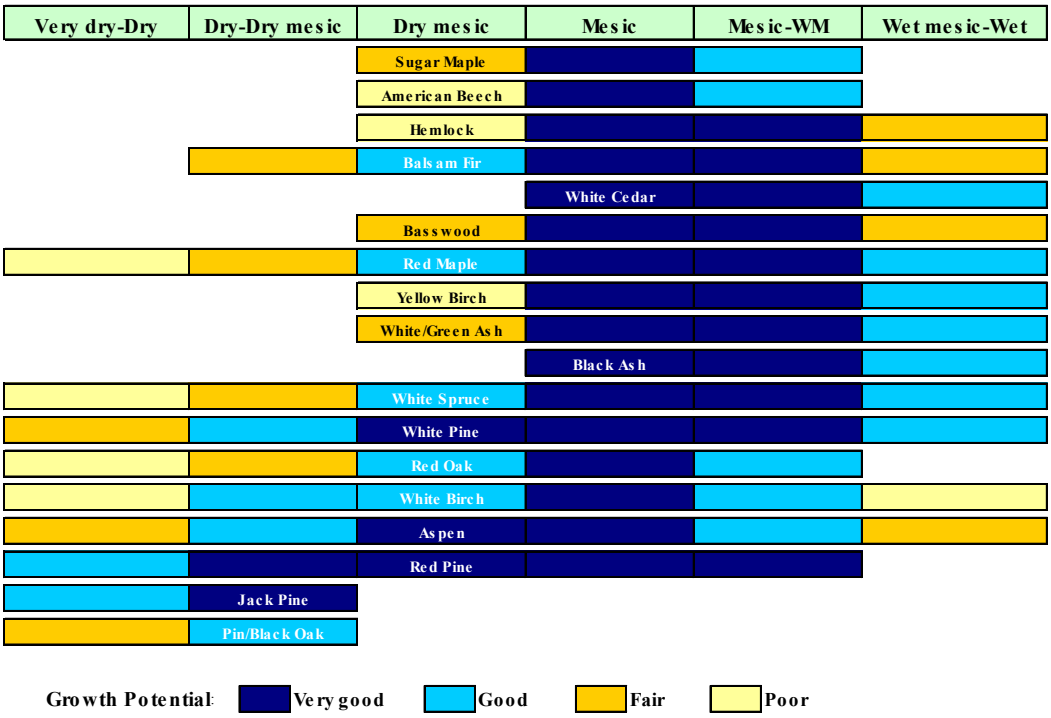


Table 12.1. Northern habitat types by group and region.
Within habitat type groups, habitat types are arranged top to bottom , from drier/poorer to moister/richer.
Types in different regions, but located on the same line are most similar in terms of management implications.

Habitat Type Group	Region 1	Region 2	Region 3	Region 4	Door Co.	Region 5
Very Dry to Dry	PQGCe QAp	PQG PArV-U	PQE PArV	PArVAo		
Dry to Dry-mesic	PArVAm	PArVAa-Po	PArVAa	PArVAa-Vb,PArVPo		PArVHa
Dry-mesic	AVDe AAt	AVCl ACl	AVVb AVb	AVb	TFAa ATFPo	AVb-V AVb
Mesic	ACaCi	ATM AAs	ATM ATD AOCa, AH	ATM AFVb ATFD ATDH AFAd AH	ATFSt AFAl	ATM AHVb AH
Mesic to Wet-mesic	ArVRp ASaI	ArAbVCo ArAbSn AAtRp ASnMi	ArAbVC TMC, ArAbCo ATAtOn ACaI, AHI	ArAbVC TMC ATAtOn AHI		PArVRh TMC ATAtOn AHI

Table 12.2. Southern habitat types by group and region.
Within habitat type groups, habitat types are arranged top to bottom , from drier/poorer to moister/richer.
Types in different regions, but located on the same line are most similar in terms of management implications.

Habitat Type Group	Region 6	Region 7	Baraboo	Region 8	Region 9	Region 10	Region 11
Dry	PVGy PVHa, PVCr	PVGy PVCr			PEu PVG		
Dry-mesic	ArDe-V AArVb ArCi, ArCi-Ph	ArDe-V ArCi-Ph	ArDe-V AArL		ArDe AQVb-Gr		
Dry-mesic to Mesic		ATiDe(Pr) ATiDe	ATiDe-Ha ATiDe-As	ATiCr(O), ATiCr(As)	ATiFrCi	ATiFrVb(Cr) ATiFrVb	AFrDe, AFrDe(Vb) AFrDeO
Mesic	ATiSa-De ATiCa-La	ATiSa ATiCa	ATTr ATiCa-Al	ATiAs(De) ATiH		ATiFrCa(O) ATiFrCa	AFTD, AFH AFAs, AFAs-O
Mesic to Wet-mesic	PVRh	PVRh					

Wisconsin Forest Habitat Type Classification System

John Kotar, Joseph Kovach and Timothy Burger
University of Wisconsin-Madison

Foresters typically classify and map forests by

Forest Cover Type

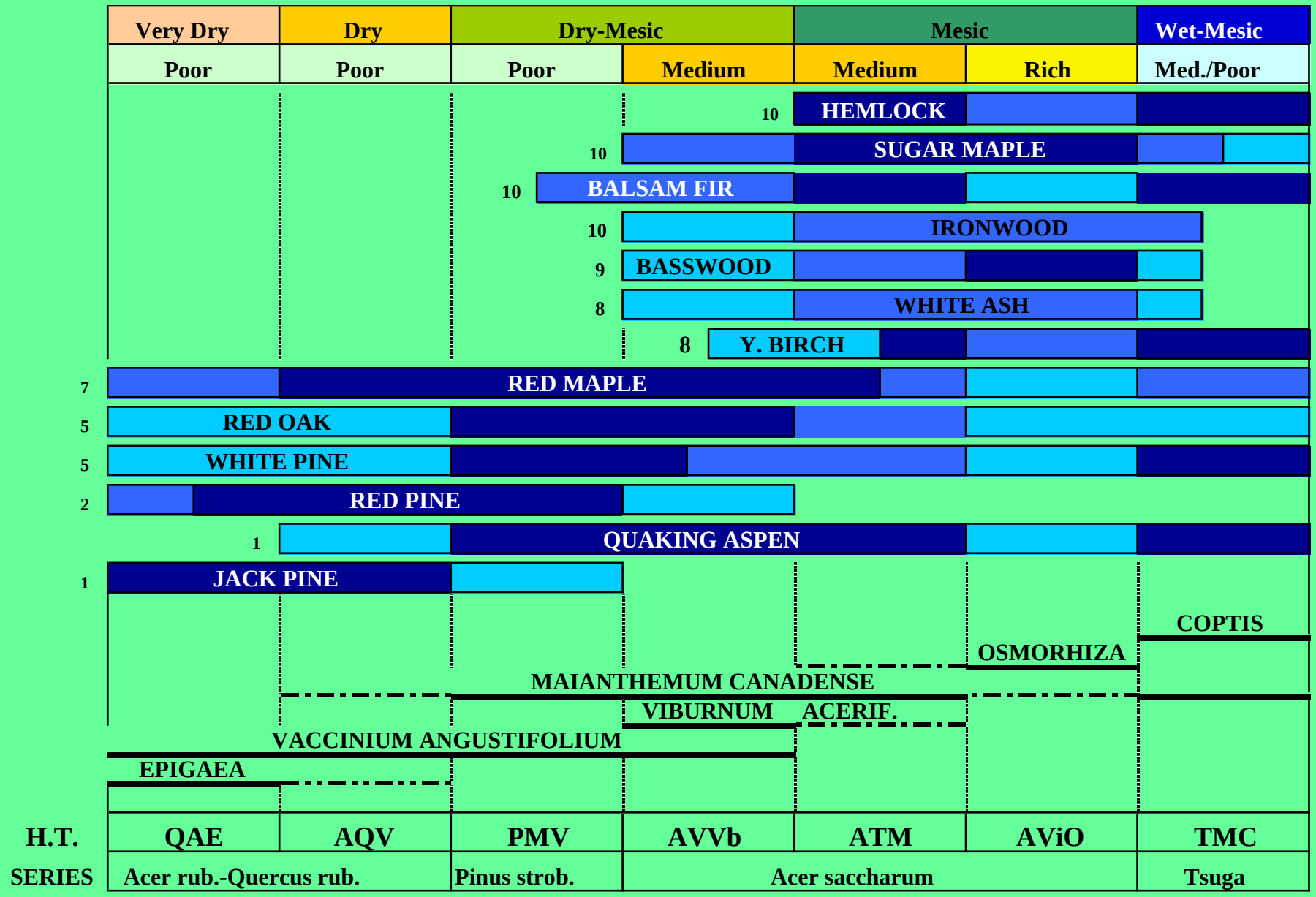
Cover Types do not necessarily reflect site conditions

e.g., a jack pine forest is not always “xeric”

and

a sugar maple-basswood forest is not always “mesic”

Species occurrence on habitat types spanning the moisture-nutrient gradient



John Kotar, University of Wisconsin-Madison

Habitat Types are identifiable by distinct Assemblages (Associations) of understory plants

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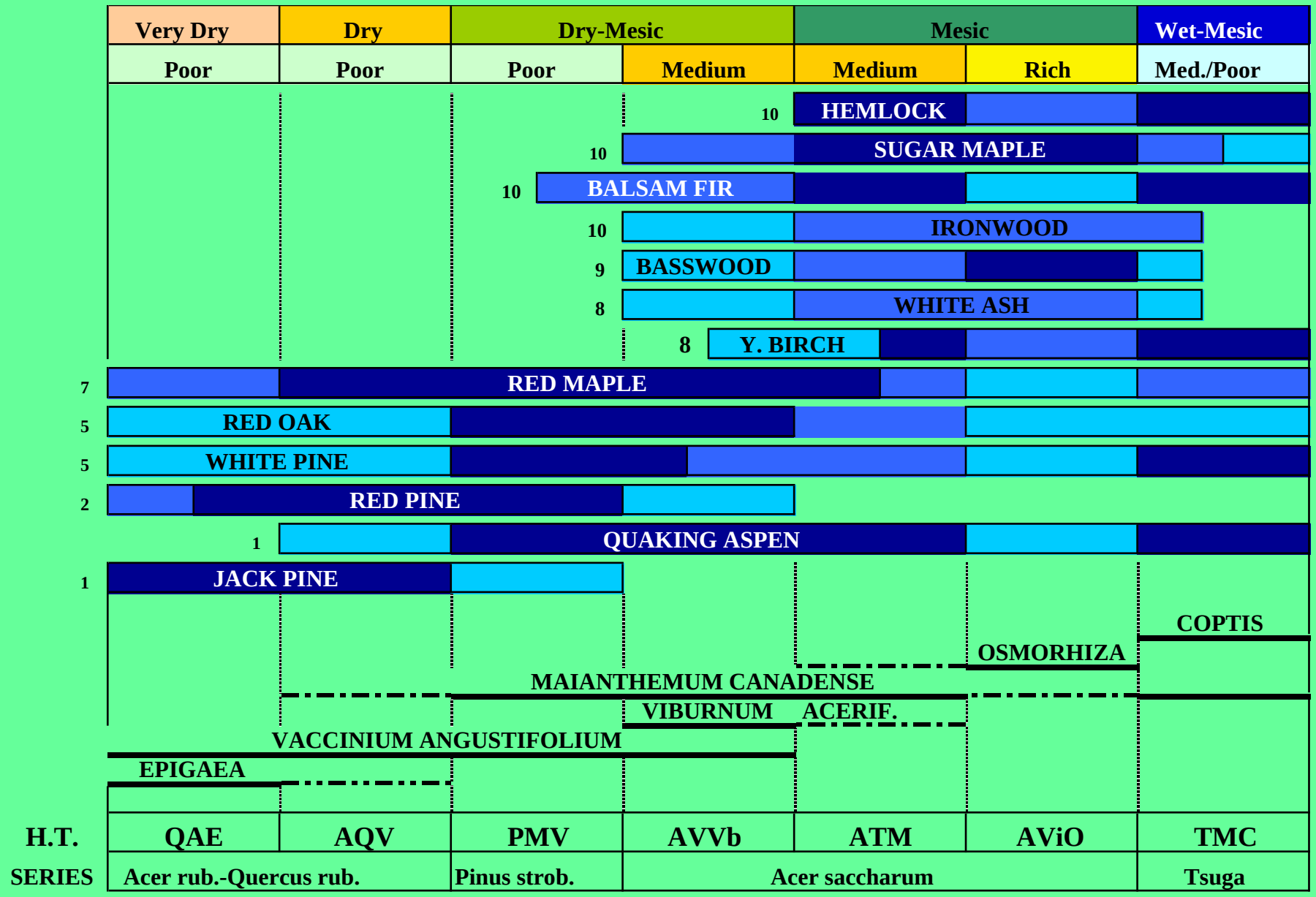

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Habitat Types are identifiable by distinct Assemblages (Associations) of understory plants

Plot number

Species	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Actaea rub		1		1	2	1		1	2			2			1	1				1			2		2	2			2	1			1	
Allium tri												2			1	1				1					1					2			1	1
Amelanchier sp.	1	1	2	3	1			2	2				3	1	1	2	1	1	1	1	1	2	2	1	1	1	2	2	2	1	2	1	1	2
Amphicarpa brac											1		2	3	1			1	1								1		2	1	1	1		
Aralia nud		2		3	1	2			1		1	1	1	2	3	1		2	1			1	2	1	1	1	2		3	2	2		2	1
Arisaema tri		2			1	2						1			1					1			1		1	2				1			1	1
Aster mac	1	1	2	3	1	2	2	2	1	2	3	1	4	4	1	1	2	4	4	2	1	2	1	3	2	2	3	1	4	1	3	4	2	1
Caulophyllum thal					2	2			1			1		1		1				2			1			1				1			1	2
Chimaphilla umb	1						2			2														1				1						
Cladina sp.	1		2							2	1		1				1				2			1				1						
Clintonia bor		1	1					2	1		1	1	1	2	1	1			2							2	1		1	1		2		
Comptonia per	4		3				3			4							3				4													
Corylus corn	3	1	3	4	1	1	4	3	1	2	3	1	2	1	1	2	3		2	1	3	2	2	2	1	1	2	4	2	2	2	3	2	1
Desmodium glut		1						2			2		1	1					1			1					3		2	1		1		
Diervilla lon	1		2	2			1	1		1	2			2			1	1	2				1						1		2			
Dryopteris spin				2	2	2		3	1		1		2		1	1		1		2		1	2		1	1	2	1	2	2	2		2	1
Epigaea rep	1		1				1			2	1						2	1	1		1			1				1						
Galium bor	1		1														1		1		1			1				1						
Galium tri		2		1	2	1	1		2		1			1	1	2		2	1	1		1	1		1		1			2	1	1	1	
Gaultheria pro	1		2	1			2	1		2	2		2	1			2	3	2		1	2		1				1			1	1		
Hamamelis virg				2								1	1	1				2	2			1							1					
Maianthemum can	1	2		4	1	4	1	2	1	1	3	2	4	4	1	2		4	2	1	1	3	1	1	1	1	3		4	2	4	3	1	1
Melampyrum lin	2		1				2			1											2			1				1						
Osmorhiza clay		3		1	2	1			2			2			2	1				3					3		1			2	1	2	4	3
Polygala pau								2				1		1				2				1		1			1		1		1			
Pteridium aqui	3	1	4	1			4	2	1	3	3	1	2	2	1		4	3	2		4	3		4				3	2		2	1		
Rosa sp.	1		1				1			1	1		1				1											1						
Rubus sp.	1		2	2	1	1	2	2	1	1	2		2	2	1	1		2		1	1	1	1	1		1	4	1	3	2	3	2		1
Sanguinaria can		2			1				2														1		1	1				1			1	
Thalictrum dio				2	1			1			1		1																		1	1		
Vaccinium sp.	4		4	1			4	2		4	2		2	1			4	1	2		4	4		4			2	3	1		1	1		
Viburnum acer				1				2			1		2	2					3	1		2		1			2		2	1	3	2		
Waldstenia frag	1		1	1			2							1			1	1	2		2	2		3			1	2	2	1	1	1		

Plot number

Species	1	22	11	29	18	8	25	4	23	12	19	14	32	20	9	28	15	5	30	33	7	31	13	24	3	21	10	34	16	27	17	6	35	26
Maianthemum can	1	1	1			1	1		3	3	4	4	4	2	2	3	4	4	4	3	4	2	2	1	2	1	1	1	1	1	2	1	1	1
Aster mac	1	1	2	1	2	2	3	2	2	3	4	4	3	4	2	3	4	3	4	4	2	1	1	1	1	2	1	2	1	2	1	1	1	2
Corylus corn	3	3	2	4	3	4	2	3	2	3		2	2	2	3	2	1	4	2	3	1	2	1	2	1	1	1	2	1	1	2	1	1	1
Rubus sp.	1	1	1	1		2	1	2	1	2	2	2	3		2	4	2	2	3	2	1	2		1		1	1		1	1	1	1	1	
Amelanchier sp.	1	1		2	1		1	2	2		1	3	2	1	2	2	1	3	2	1		1		2	1	1	2	1	1	1	2	1	2	1
Vaccinium sp.	4	4	4	3	4	4	4	4	4	2	1	2	1	2	2	2	1	1	1	1														
Gaultheria pro	1	1	2	1	2	2	1	2	2	2	3	2	1	2	1		1	1		1														
Waldstenia frag	1	2		2	1	2	3	1	2		1		1	2		1	1	1	2	1		1												
Pteridium aqui	3	4	3	3	4	4	4	4	3	3	3	2	2	2	2		2	1	2	1			1		1		1		1					
Diervilla lon	1		1		1	1		2		2	1		2	2	1		2	2	1					1										
Aralia nud							1		1	1	2	1	2	1		2	2	3	3		2	2	1	2	2		1	2	3	1	1	1	1	1
Dryopteris spin				1					1	1	1	2	2		3	2		2	2		2	2		2		2	1	2	1	1	1	2	1	1
Clintonia bor								1		1		1		2	2	1	2		1	2		1	1		1		1		1	2	1				
Galium tri						1			1	1	2		1	1		1	1	1		1	1	2		1	2	1	2	1	1		2	2		1
Melampyrum lin	2	2	1	1		2	1	1																										
Epigaea rep	1	1	2	1	2	1	1	1		1	1			1																				
Comptonia per	4	4	4		3	3		3																										
Cladina sp.	1	2	2	1	1		1	2		1		1																						
Chimaphilla umb	1		2	1		2	1																											
Galium bor	1	1		1	1		1	1						1																				
Rosa sp.	1		1	1	1	1		1		1		1																						
Viburnum acer							1		2	1		2	3	3	2	2	2	1	2	2		1				1								
Polygala pau							1		1		2		1		2	1	1		1				1											
Desmodium glut									1	2		1		1	2	3	1		2	1		1			1									
Hamamelis virg									1		2	1		2			1	2	1				1											
Amphicarpa brac										1	1	2	1	1		1	3		2	1		1							1					
Thalictrum dio										1		1	1		1			2		1												1		
Osmorhiza clay													1			1		1		2	1	2	2		3	3	2	4	2		1	2	3	3
Caulophyllum thal																	1				2	1	1	1		2	1	1		1	1	2	2	
Arisaema tri																					2	1	1	1	2	1		1	1	2		1	1	1
Actaea rub															1			1	2		1	1	2	2	1	1	2	1	1	2	1	2		2
Sanguinaria can																						1		1	2		2	1		1		1		1
Allium tri																						2	2			1		1	1		1		1	1

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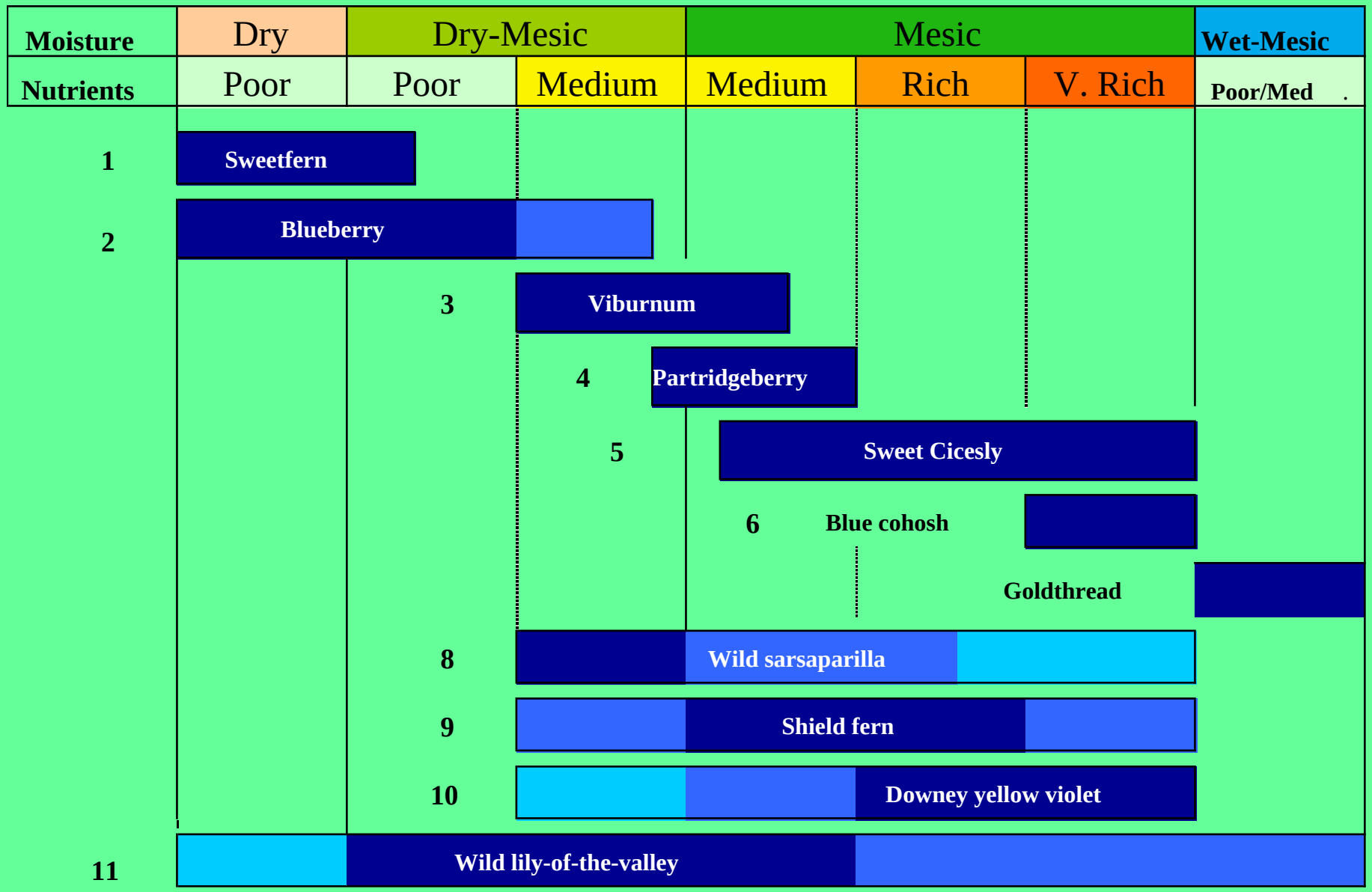
Ecological Species Groups of Northern Wisconsin's Upland Forests



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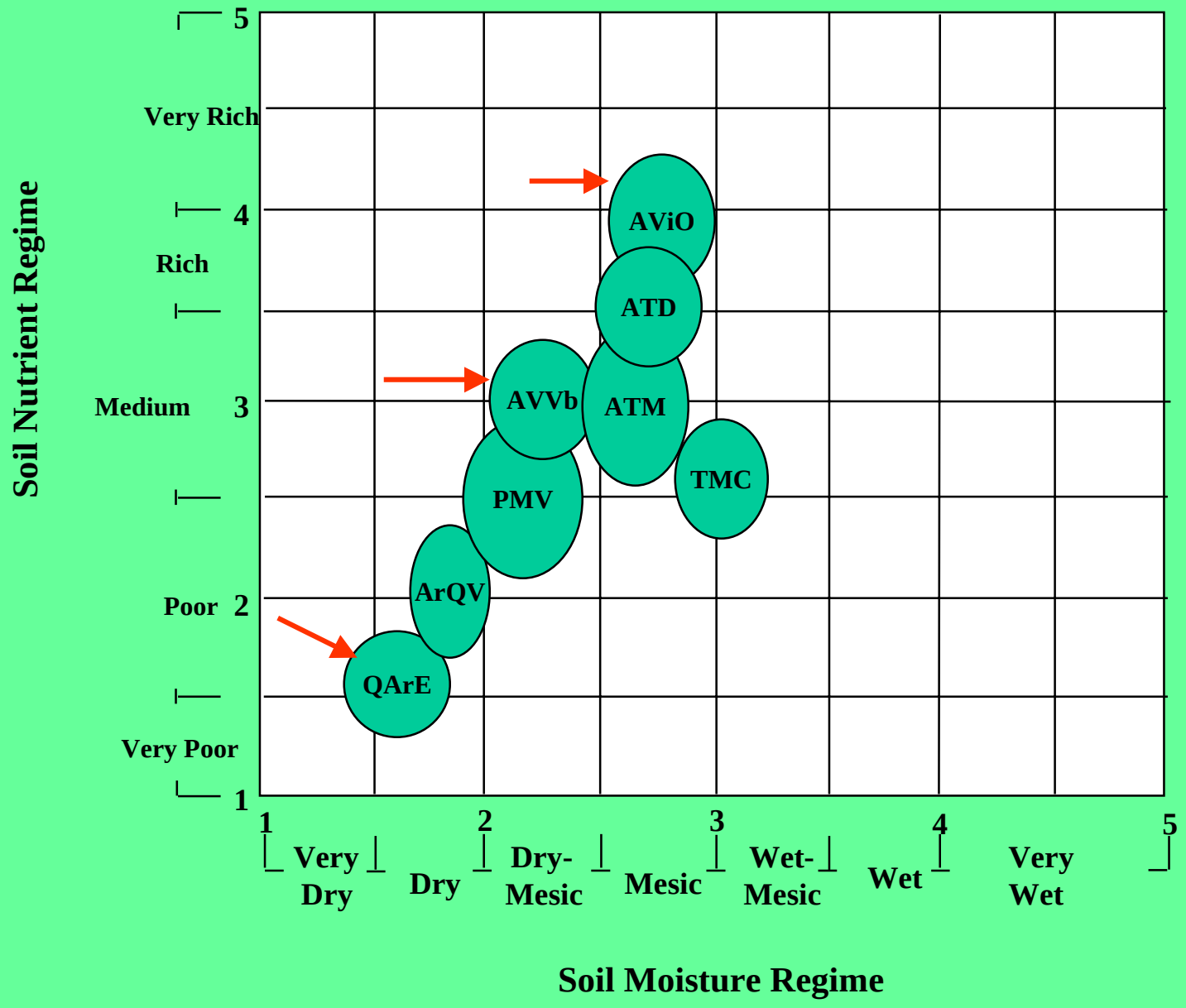
Habitat Types of Wisconsin's Region 3



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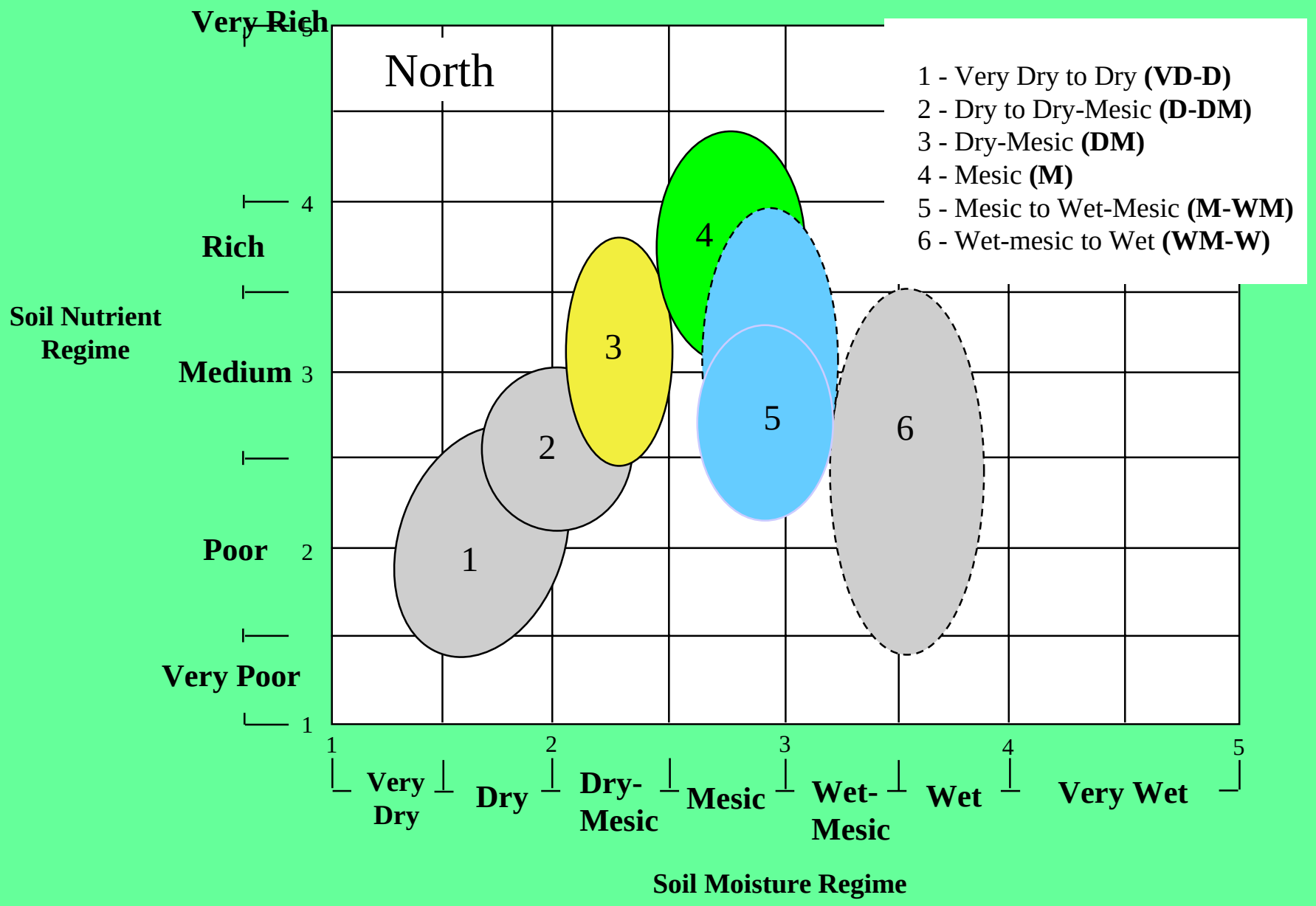
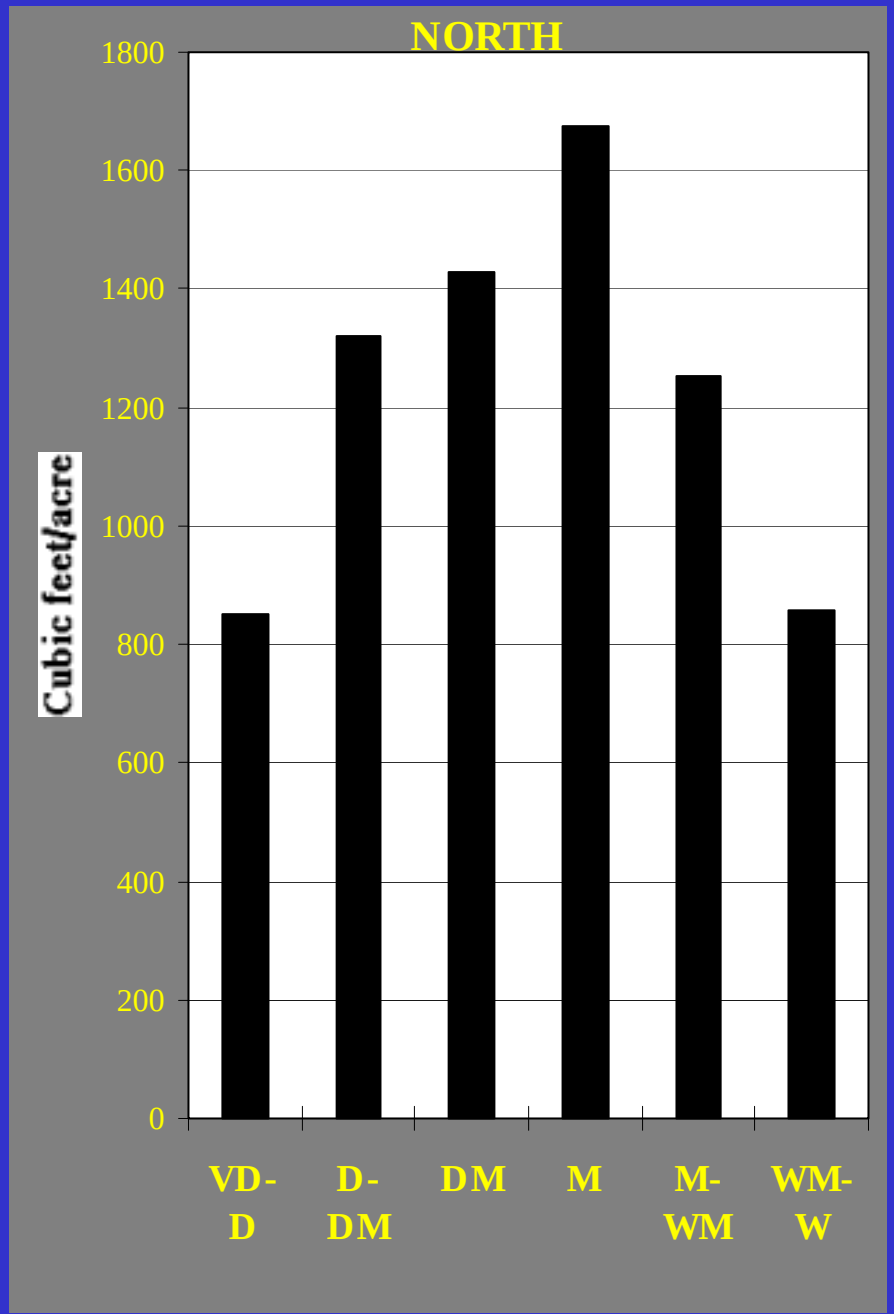
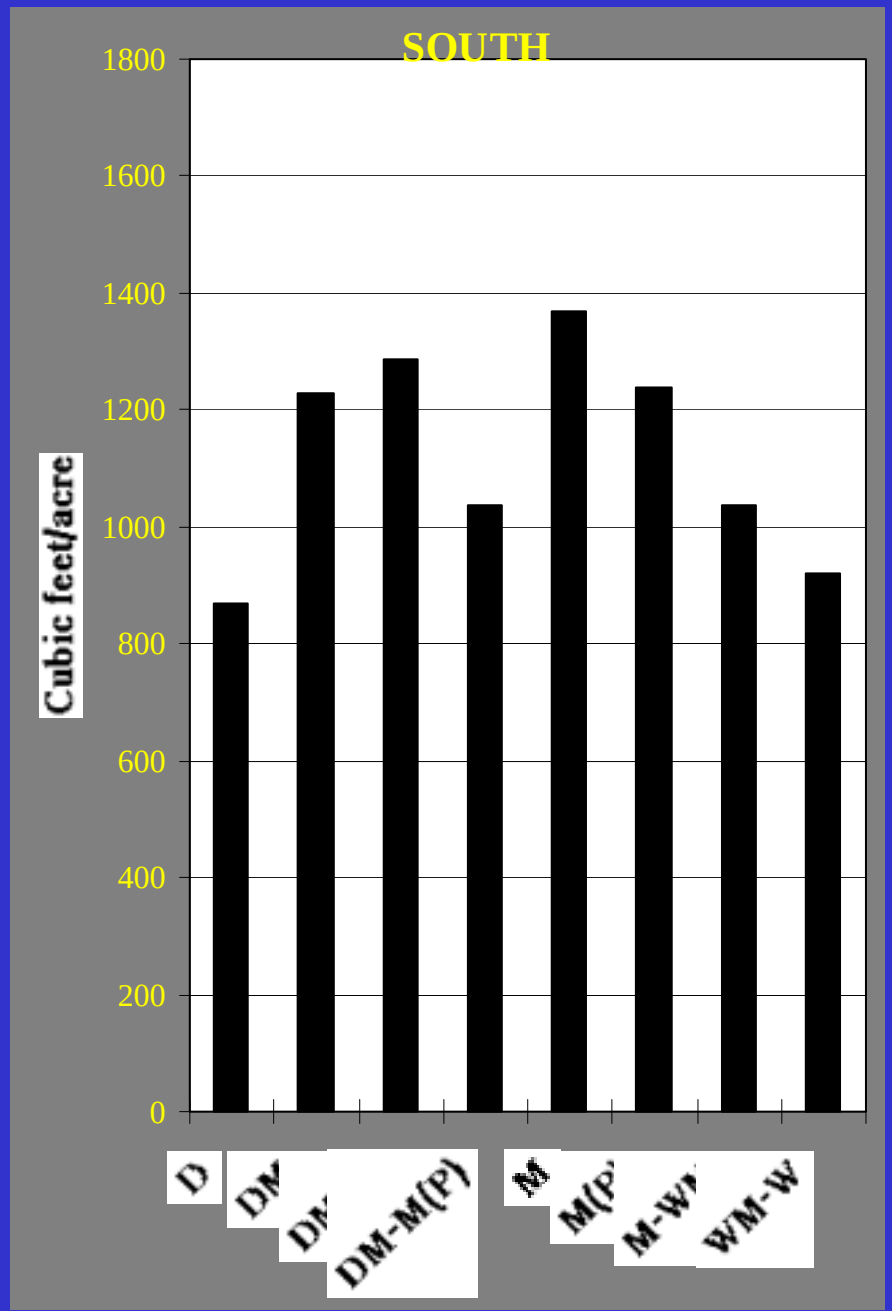

North
1 - Very Dry to Dry (VD-D)
2 - Dry to Dry-Mesic (D-DM)
3 - Dry-Mesic (DM)
4 - Mesic (M)
5 - Mesic to Wet-Mesic (M-WM)
6 - Wet-mesic to Wet (WM-W)
Soil Nutrient Regime
Very Rich
Rich
Medium
Poor
Very Poor
1
2
3
4
5
Very Dry
Dry
Dry-Mesic
Mesic
Wet-Mesic
Wet
Very Wet
Soil Moisture Regime

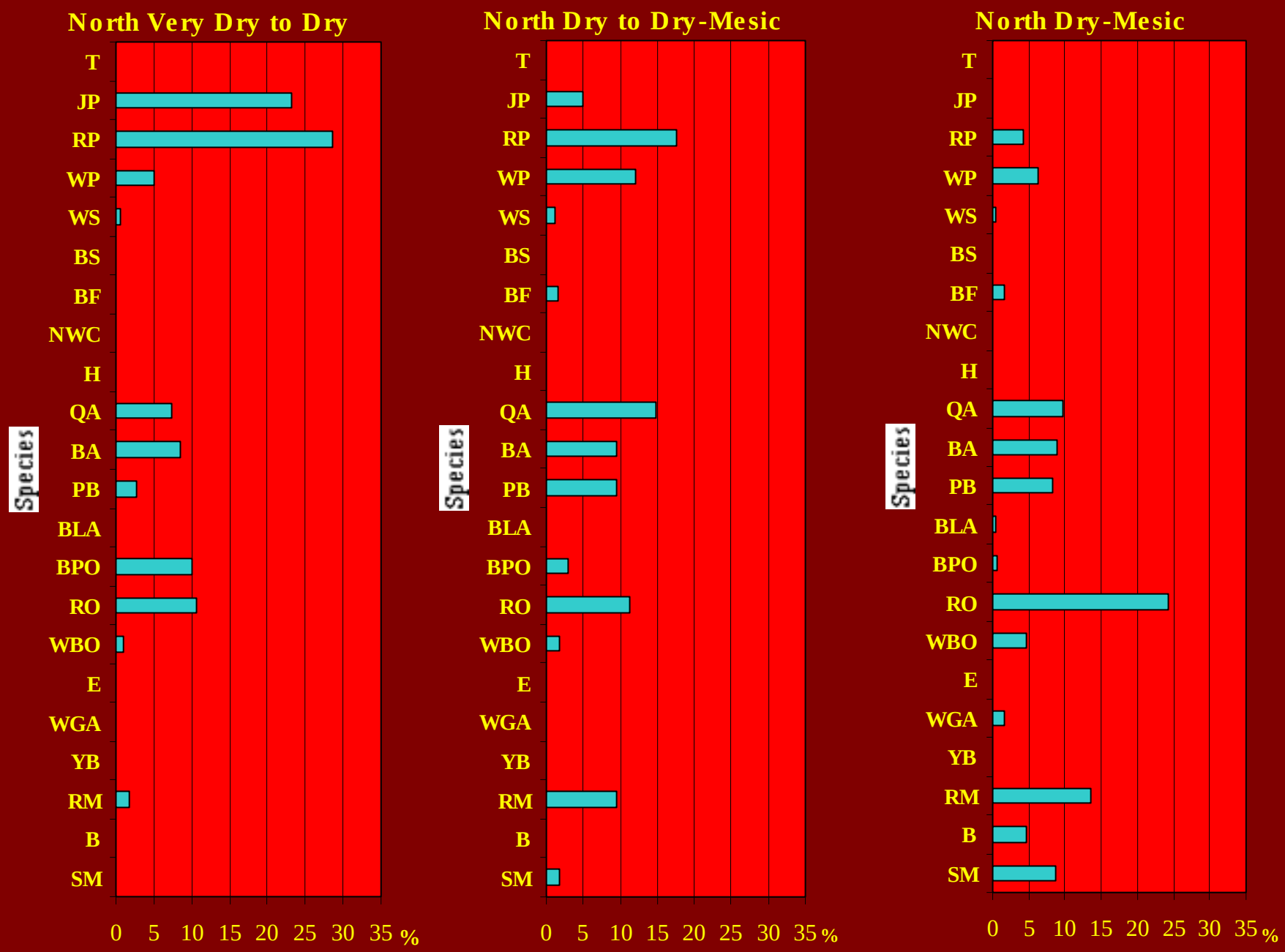
Growing Stock Volume per Acre by Habitat Type Group



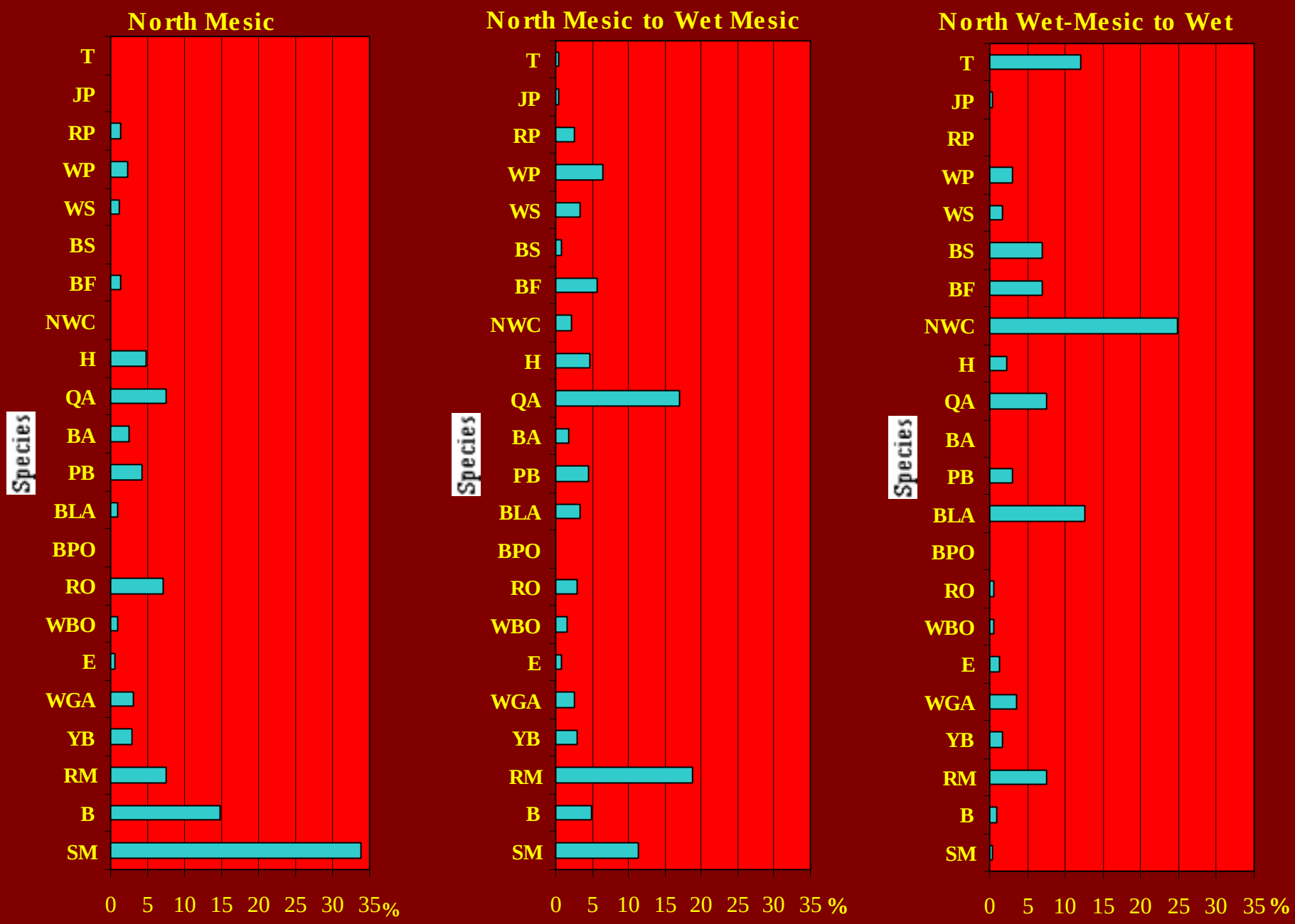


Average volume per tree (cubic feet) across habitat type groups						
	Very Dry to Dry	Dry to Dry-Mesic	Dry-Mesic	Mesic	Mesic to Wet-Mesic	Wet-Mesic to Wet
Jack Pine	5.6	6.9				
Red Pine	7.8	12.0	9.4	9.3		
B.T. Aspen	9.2	12.4	11.7	14.1	11.0	
Q. Aspen	5.6	7.7	8.6	9.2	8.1	7.5
Red Oak	7.3	10.3	14.6	19.6	15.9	
White Pine		18.3	22.8	43.2	28.1	19.9
Paper Birch		7.1	6.8	8.5	7.1	5.7
Red Maple		5.1	6.0	7.9	7.0	7.3
Sugar Maple			7.7	9.6	8.7	
Basswood			9.3	12.7	12.9	*
Yellow Birch				10.5	9.7	*
Hemlock				15.5	12.9	*
Balsam Fir				5.4	4.7	3.8
White Ash				11.2	9.8	8.8
N.W. cedar					6.8	5.2
W. Spruce					10.4	
Black Ash					6.6	5.6
Blk. Spruce						3.6
Tamarack						5.3

Species Composition of the Northern Habitat Type Groups as a Percent of the Total Group Volume

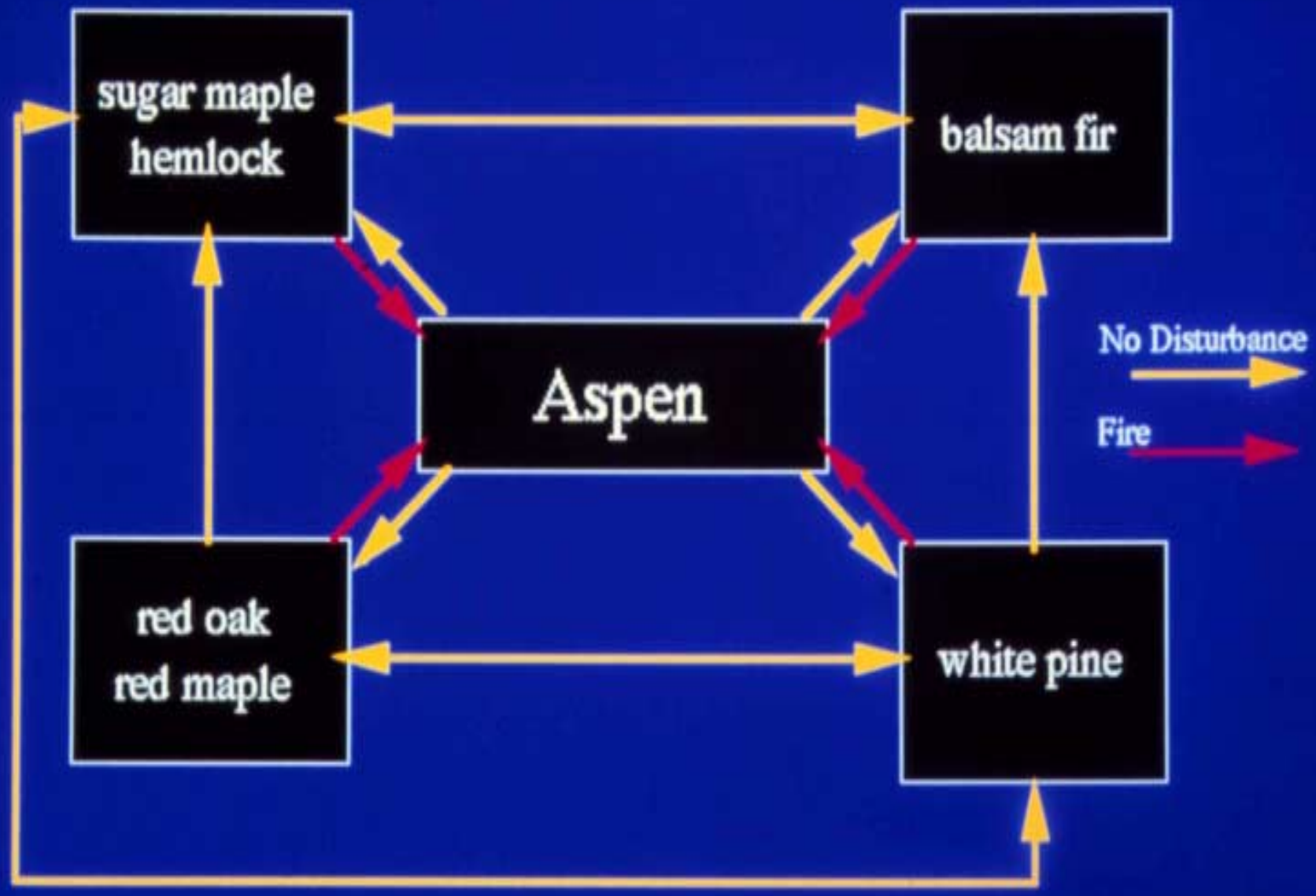


Species Composition of the Northern Habitat Type Groups as a Percent of the Total Group Volume



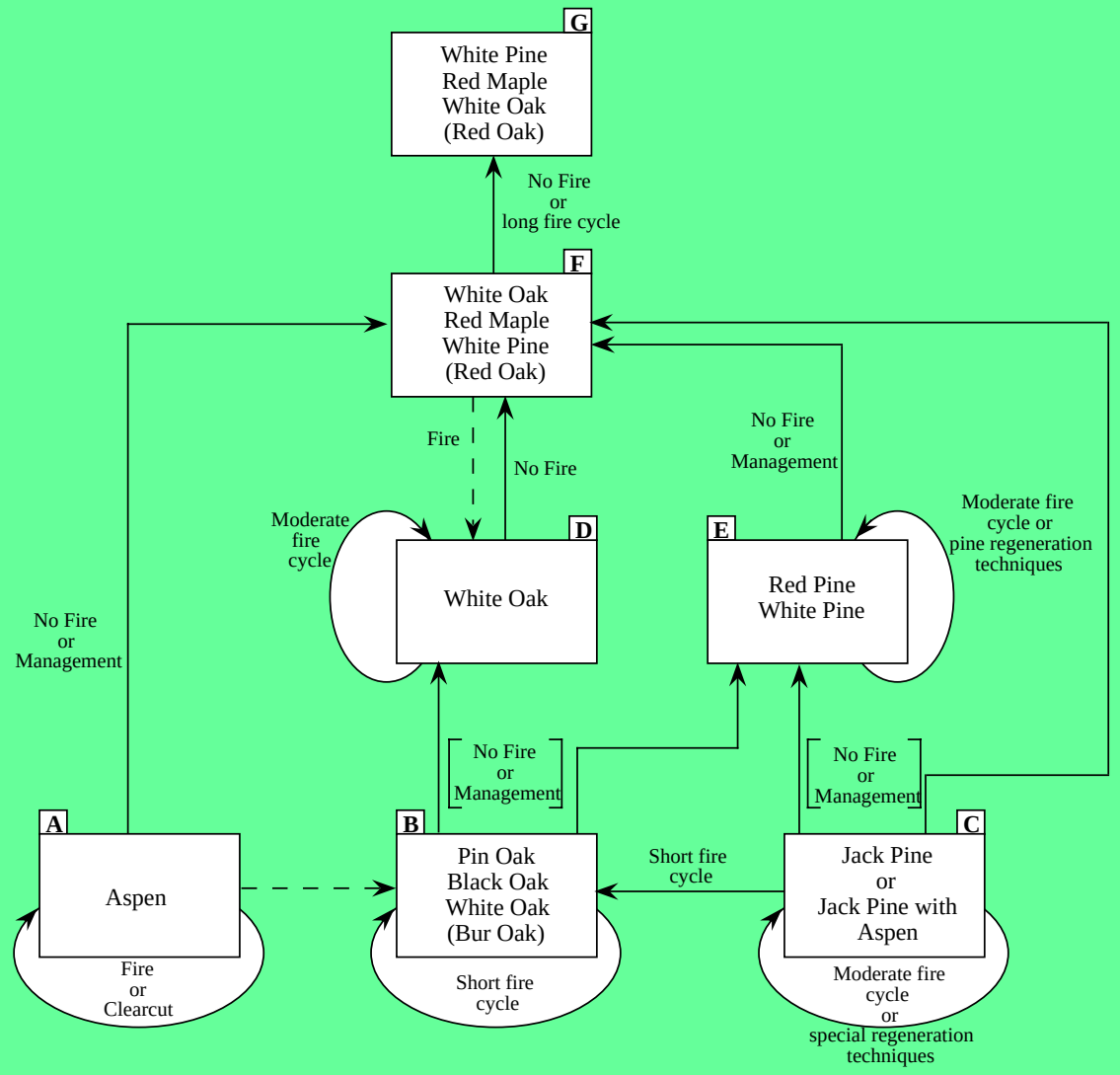
(John Kotar, University of Wisconsin-Madison)

Potential Successional Changes of an Aspen Stand



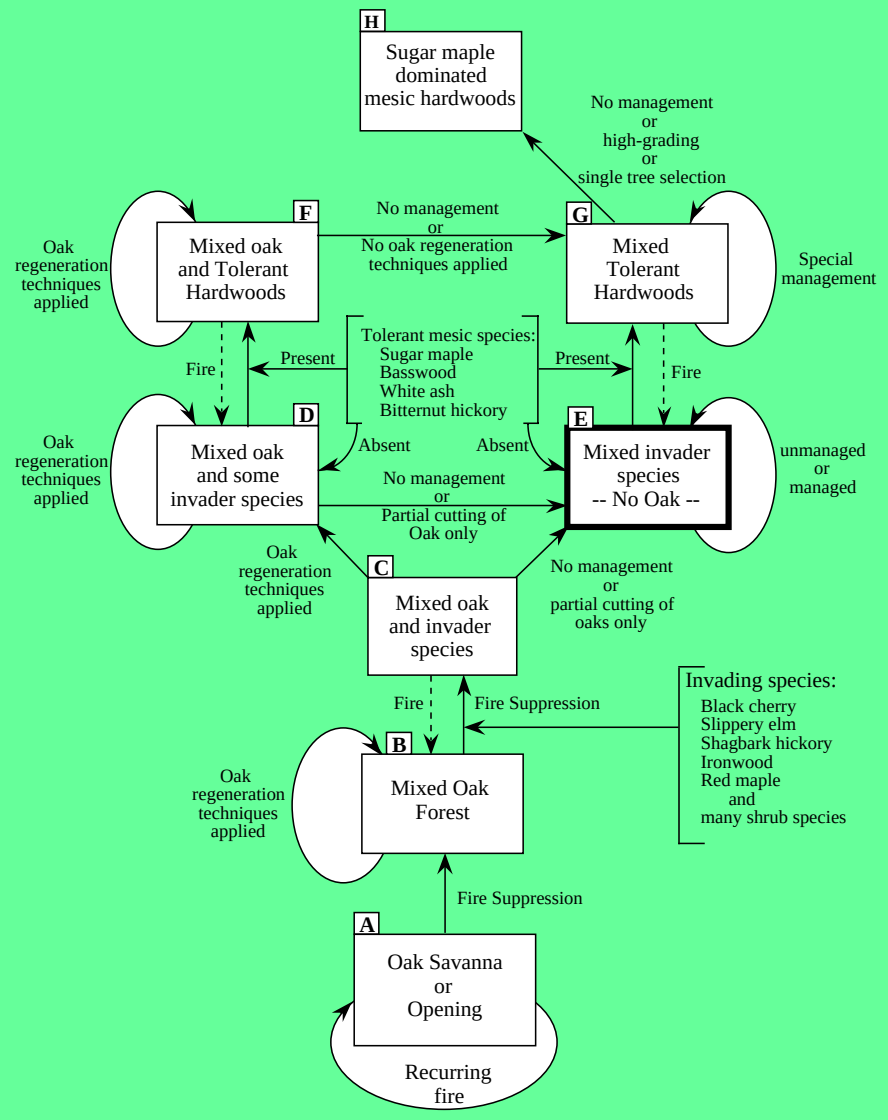
Forest Community Dynamics on Dry Sites

(with or without management)



John Kotar, University of Wisconsin-Madison

Forest Community Dynamics (with and without management) on Mesic and Dry-mesic Sites in Southern Wisconsin



John Kotar and Timothy Burger; Department of Forestry, University of Wisconsin-Madison

Forest Community Matrix for Baraboo Hills

(John Kotar, University of Wisconsin-Madison)

Habitat Type						
Successional Stage	**Size/age class**	**ArDe-V**	**AArL**	**ATiDe-Ha**	**ATiCa-Al**	**ATTr**
Early (30-50 yrs)	Large/ Old	**Aspen**	**Aspen**	**Aspen**	**Aspen**	**Aspen**
	Med./ Med.	**Pin oak Black oak**	**Red oak White oak**	**Basswood White ash**	**White ash Basswood**	**White ash**
	Small/ Young	**Red oak White oak White pine**	**Red maple White pine White oak**	**Red maple Basswood Sugar maple**	**White ash Basswood Sugar maple**	**Sugar maple Y. birch Hemlock**
Mid- (50-80 yrs)	Large/ Old	**Pin oak Black oak Aspen**	**Red oak White oak Aspen**	**Basswood White ash Aspen**	**White ash Basswood Aspen**	**Sugar maple Y. birch Aspen**
	Med./ Med.	**White pine Red oak White oak**	**Red maple White pine White oak**	**Basswood Red maple sugar maple**	**Sugar maple**	**Sugar maple Y. birch Hemlock**
	Small/ Young	**Red maple White oak White pine**	**Red maple Ironwood Sugar maple**	**Sugar maple Ironwood Basswood**	**Sugar maple Basswood Ironwood**	**Sugar maple Y. birch Hemlock**
Late (80+)	Large/ Old	**White pine Red oak White oak**	**Red oak White oak White pine**	**Sugar maple Basswood White ash**	**Sugar maple Basswood White ash**	**Sugar maple Y. birch Hemlock**
	Med./ Med.	**Red maple White pine White oak**	**Sugar maple Ironwood Red maple**	**Sugar maple Basswood Ironwood**	**Sugar maple Ironwood Basswood**	**Sugar maple Y. birch Hemlock**
	Small/ Young	**Red maple White oak White pine**	**Sugar maple Red maple Ironwood**	**Sugar maple Ironwood Basswood**	**Sugar maple Ironwood Basswood**	**Sugar maple Hemlock Y. birch**