-Forest Environment-

Forest Ecology and the Ever-Changing Forest

Adapted from the on-line Teachers Guide
http://mff.dsisd.net

MICHIGAN STATE UNIVERSITY EXTENSION

<u>SUCCESSION AND FOREST CHANGE</u>

<u>What Is Succession?</u>

<u>Succession is one of the most important concepts</u> in natural resource management. The fact that "nature" is always changing is critical in appreciating management systems and natural processes.

Succession is predictable if enough is known about a specific site and most of the factors that influence succession at that place and in that time. A series of vegetation types in a given area is a ***"successional pathway"*** or ***"sere"***. A single vegetation type within a sere is called a ***"seral stage"***. In Michigan, a forester or ecologist will usually be able make fairly accurate predictions of succession.

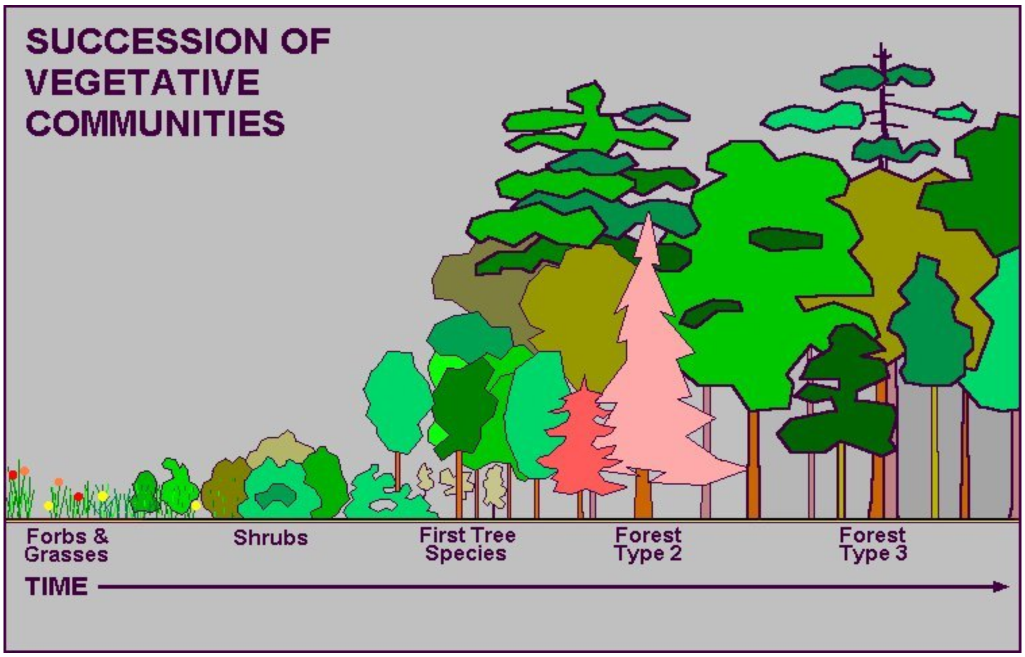
> *Succession: The gradual supplanting of one community of plants by another.*
>
> Note 1- *The sequence of communities is called a* ***sere****, or seral stage.*
>
> Note 2- *A sere whose first stage is open water is termed a* ***hydrosere****, one whose first stage is dry ground, a* ***xerosere****.*
>
> Note 3- *Succession is primary (by* ***pioneers****) on sites that have not previously borne vegetation, secondary after the whole or part of the original vegetation has been supplanted,* ***allogenic*** *when the causes of succession are external to and independent of the community (e.g. accretion of soil by wind or water, or a change of climate), and* ***autogenic*** *when the developing vegetation is itself the cause.*
>
> *-Society of American Foresters, 1998*

With forests, trees are the dominant life form and it is these associations of trees that give rise to the names of forest types. These types are often names of individual seres within a successional path. For instance, an aspen stand may be taken over by red maple and balsam fir. Decades later, sugar maple may become dominant. On richer soils, the number of potential successional pathways increase. On an infertile, dry, sandy soil, jack pine might be the only forest type that will occur. On a wet soil with ***microtopography***, northern white cedar might maintain itself for centuries.

The progressive change in forest types has a huge impact on the complement of wildlife species and ***understory*** plant species that live there. The forest type will also influence soil development, erosion potential, soil pH, organic matter volume, water retention, water quality, and similar forest characteristics. Forest types also have visual components that influence the way people perceive forests.

Microtopography: The small scale bumps and holes on a forest floor. In a wetland soil, trees will grow on the bumps but not in the holes. Tree roots typically do not grow in saturated conditions. When trees blowdown and are uprooted, they form "pit and mound" topography. The root ball and tree trunk form "mounds". The hole from where the roots came is the "pit". On richer upland sites with thick layers of organic matter, the exposed mineral soil from blowdowns are one of the few places for some tree seeds to successfully germinate.

Understory: Forest vegetation is usually arranged in "layers", from the ground to the top of the forest canopy. The biggest trees are called dominants or codominants. The next layers are shorter trees either pushing their way into the canopy or suppressed (sickly) by the shade. Sapling trees and shrubs for the "understory". Below the understory are the small plants, herbs, grasses, ferns, etc.



Successional change is not abrupt, but quite gradual. Some plants and animals are specific to a particular vegetation or forest type and are rarely present in earlier and later seres. Most plants and animals are more general in their habitat strategy, often finding habitat needs in a variety of vegetation types. Most plants and animals can also get by through using their "second" or "third" choices of preferred habitat. Plants and animals that are very specific and narrow in their habitat needs are often indicator species of particular condition or vegetation type. If these species occur in low number in few places, they are usually on either the federal or state endangered / threatened species list.

Case Study: Kirtland's warbler is small migratory bird closely and nearly exclusively associated with young, moderately open stands of jack pine while they in the north for the breeding and summer season. Early logging, subsequent fires and agricultural failure almost drove Kirtland's warbler to extinction. Through active management of jack pine age structure and stand size, the warbler has made a successful comeback. Managing jack pine successional was a critical element in bringing this bird back from the brink of extinction.

What Drives Successional Change?

There are biological (biotic) factor and non-biological (abiotic) factors that drive succession.

Biological factors usually involve plants, but sometimes animals. In forests, trees are generally the primary biotic driver. To understand how trees cause succession, you have to know about the habitat requirements for various tree species. The most important requirement, in terms of succession, is soil characteristics and a tree's tolerance of shade.

Animals influence succession in a number of ways, too. A major insect epidemic that kills trees, will usually setback succession to an earlier stage. High populations of white-tailed deer over a decade or more will selectively remove some species from a forest type. Crippling the successful regeneration of most (or all) tree species will have major impacts on the succession of plant communities.

Abiotic factors are such things as soil types, moisture levels (swamp vs. upland), weather, and climate. Red pine / red oak forest types grow on sandier, well-drained soils. Cedar, black spruce, and tamarack types typically grow in swamps. Weather impacts succession in the form of windstorms, droughts, late spring frosts, etc. Climate differs from weather in terms of time and geography. Climate change generally occurs over very long periods of time and across large regions. Weather is more variable from year to year and has more localized impacts.

> *Case Study Abiotic Factors: American beech distribution dramatically stops in the Upper Peninsula where soil types change from richer glacial deposits in the east to low fertility soils derived from granitic bedrock in the west. Most hickories, many oaks, sassafras, and sycamore are central hardwood tree species that only grow in southern Michigan's milder climate. On the other hand, the pines and spruces are more adapted to the colder climates and soils of northern Michigan.*

Fire is a particularly strong abiotic factor in succession. Many of our forest types have adapted to regular wildfires. Minnesota forests bordering the prairie are almost entirely comprised of forest types adapted to frequent fires. Frequent fire and a drier climate have resulted in a forest with fewer tree species and forest types. In the Upper Peninsula of Michigan, many forest types have developed where wildfire is often less frequent and average rainfall is higher.

Succession Case Study

A young aspen stand lacks much height but has many stems per acre. Because aspen is intolerant of shade, we know something catastrophic occurred about 10-15 years ago, maybe a harvest or maybe a windstorm or fire. In any case, the aspen is regenerating well. There is often a diversity of other tree species, such as black cherry, oak, and paper birch. The high number of stems provides good breeding and escape cover for animals such as rabbits and grouse. Deer heavily browse the young trees. The vigorous young trees actively transpire large quantities of water and produce much more oxygen than they use. Beavers and broad-winged hawks prefer this forest type.

As the aspen ages, the trees will thin themselves out and the forest will become taller and less dense. Grouse love the more mature flower buds but will prefer raise their young elsewhere. The aging aspen will provide uses for red-eyed vireos, woodpeckers, and maybe some owls. Mature aspen allow a fair amount of light to reach the forest floor, so there is still an actively growing understory. On sandy soils, hazel may be common, whose nuts are important food for many animals. On heavier soils, there may be buckthorn, Juneberry, and viburnums. It's also likely that the seedlings from more shade tolerant tree species have begun to grow. They will make up the next forest type.

On sandier and dryer soils, the next forest type might be a mix of white or red pine, oak, and red maple. On heavier soils, the new generation might be sugar maple, balsam fir, and white spruce. There are about 35 tree species in Michigan aspen associations, second in diversity to only northern hardwoods. Left unmanaged, over a number of decades, the aspen will eventually die out. The next type might be a white pine-red oak association, or a northern hardwood stand. In wet soils, cedar might become dominant.

Forest Disturbance

A successional path spans a long time, from the human perspective. Over the course of time, it's quite likely the stand will experience some form of disturbance. Disturbances occur from natural causes, such as wind, fire, pest infestation, or it can come in the form of timber harvest. In either case, the course of succession is altered. With forest management, the manipulation of succession is intentional, with a set of goals in mind, ideally within the context of a greater landscape.

Activity Suggestion: Research when and where a recent forest disturbance occurred near you. Was it natural? Was it human-caused? What happened? Visit the site if you can. What tree species are growing in the disturbed area that are not growing in the adjacent undisturbed area? What tree species are more abundant in the disturbed area? Why is this?

Disturbance is essential to the regeneration of many tree species. Jack pine and paper birch were largely dependent upon wildfire for regeneration. Successful fire suppression programs have created a management dilemma for these species that forest scientists needed to overcome. Northern hardwood (sugar maple, beech, basswood, and others) stands need small scale disturbances to create "holes" in the forest canopy to regenerate many species and maintain higher levels of species diversity. Selection harvest and thinning complements this natural process to produce more forest outputs in a shorter period of time.

Since the Glaciers

We typically think of succession in terms of current climate conditions and a time frame of just a century or two. Climate is one of the main drivers of succession but is not constant over the millennia. Climate change studies have demonstrated a progression of widely different successional regimes.

The climate of Michigan has varied considerably since the continental glaciers receded 10,000 - 12,000 years ago. For centuries during the recession, the climate was cool and moist. Boreal species and plant community types extended into Indiana and Illinois. Relict populations of boreal types can still be found scattered across the normally more temperate climates.

During the current post-glacial period, climates have varied considerably from we experience now. There have been cooler moister periods where our forests had much stronger boreal characteristics. There have also been warmer drier periods where much of Michigan was prairie. That's part of the reason why Michigan still has a few prairie remnants.

FOREST ECOLOGY BASICS

A forest is a collection of biological organisms and non-biological factors. From an ecological perspective, the definition of a forest includes all these things, from the trees to the bacteria, and the soil type to the microclimates. See the "Tree Basics" chapters for more about the definition of a forest. Forest management systems are rooted in forest ecology (pun intended!).

There are three groups of concepts with forest ecology, or the ecology of just about any natural system. Each of the three groups of concepts interact with each other to variable degrees, at variable times, and in variable ways.

- **Composition**: These are the pieces of the puzzle.
- **Structure**: This is how the pieces are arranged.
- **Function**: This is what each piece does and the interactions among the pieces.

Ideas on this in this Forest Ecology section:

Diversity Populations Communities Forest Layering Crown Cover Edge Effect Fragmentation Parcelization	Snags Microenvironment Visual Quality Aesthetics Food Chains Nutrient Cycles Organic Matter	Trophic Levels Weathering Hydrologic Cycle Temperature Humidity Succession Disturbance

COMPOSITION

Composition has to do with species, taxonomy, and biological diversity. The number of species and how they relate to each other according to taxonomic classes is a reasonably straight-forward concept. *Biological diversity*, on the other hand, is a bit more slippery to wrap our minds around. At first, diversity sounds like a simple species count and relative abundance of each species. This is certainly a component of the diversity question. It's also the easiest to identify and study. However, the diversity of ***species*** is only one level of several.

Species: *the main category of taxonomic classification into which genera are subdivided, comprising a group of similar interbreeding individuals sharing a common morphology, physiology, and reproductive process. Note 1, there is generally a sterility barrier between species, or at least reduced fertility in interspecific hybrids. Note 2, the*

At the most fundamental level of diversity, there is ***genetic diversity***. How many genes and pieces of genetic information are present in a forest? The chlorophyll gene, for example, is common throughout most of the plant kingdom (although there are several variants). Many other attributes or genetic characteristics are also quite common in a forest system. Vertebrates have far more genetic commonality than genetic difference. The loss of a species may not represent a loss of genetic diversity, only the loss of particular combination of genetic material. The raw material will probably remain in the biota. If you remove the word "the" from the English language, it would make our speech awkward, but it would not eliminate all words with the letters "t", "h", and "e".

Species diversity is the next level of diversity. These are the combinations of genes that we are most accustomed to dealing with in the life sciences and from legal perspectives (e.g. endangered species laws). Yet, the definition of the word species escapes a single, concise, universally-accepted agreement. Species ***abundance*** addresses the issue of how common a particular species is, often in the context of particular region or ecosystem. There might be 100 species in a suite of characters. However, 90% of the biomass might consist of only 3 species. There may be a few species that are very uncommon, or have low abundance. It is usually the species with low abundance that we are concerned about from the perspective of potential species loss. It is usually the abundant species that we derive the most of economic base from. See the ***tree species diversity*** section at the end of this chapter for more information about Michigan forests.

A collection of individuals of a given species make up a ***population***. The size, frequency, and distributions of populations are important elements of diversity. A Canada lynx might be listed as endangered in Michigan, but across its range it is a common animal. Sometimes populations on the edge of species range will display unique set of genes. Northern populations of animals tend to have larger size and shorter appendages. Flowering times of a tree species varies with climate conditions. The conservation of distinct populations may be important in some cases.

With a given ecosystem, populations interact with other. There are identifiable associations of species. These ***species associations*** are called ***communities***. Community diversity is more difficult to measure in the landscape because there are usually a large number of components. To make identification possible, key species are used to describe a community, such as "northern hardwoods", which is defined by such tree species as sugar maple, beech, and basswood. However, northern hardwood associations in the western Upper Peninsula lose the beech component. Community descriptions have an inherent degree of variability across a large geographical region. This is another element of "diversity".

Lastly, there is something called ***"ecosystem diversity"***. A collection of communities and the association physical factors make up an ecosystem. Ecosystem diversity is commonly described in terms of biomes, eco-regions, and similar large-scale terms. However, ecosystems can also be quite small. The various communities within a rotting log are distinct from the surrounding forest. That rotting log, or all the rotting logs in a forest, can be considered an ecosystem.

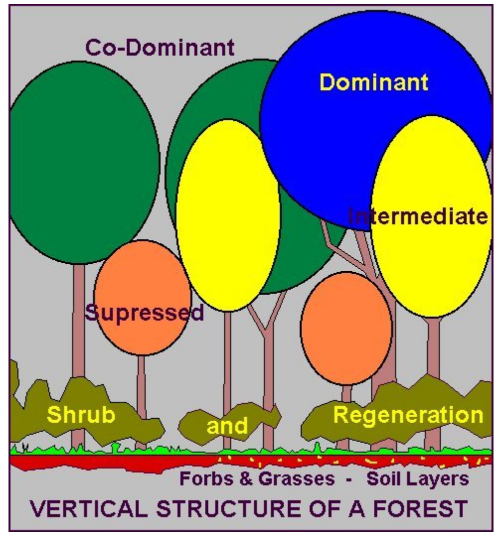
While the above levels of diversity suggest a strong hierarchy, the classifications are less distinct in the natural world. A considerable amount of flexibility and "confusion" exists. Diversity is complex set of concepts, despite our understandable tendency to reduce it to a species level.

STRUCTURE

The structure, or "architectural" arrangement of a stand and forested region is important. Structure impacts wildlife habitat in a major way. It also influences light, water, and nutrients levels. These things, in turn, impact the trees and other vegetation. Structural components of a forest, or lack of a particular component, are not inherently "good" or "bad", or "natural" or "unnatural". Structure is an ecological feature of a forest that can be measured, and subsequently evaluated against a set of criteria. Seven elements of structure are discussed.

- Vertical & Horizontal Arrangement
- Heterogeneity and Forest Density
- Edge Effects
- Islands and Fragmentation
- Dead Trees and Snags
- Micro-Environments
- Appearance

Vertical & Horizontal Arrangement



This is the physical arrangement of a forest; the different tree heights, ***"layers"*** of forest, and the continuity of branches from tree to tree. A forest with more structure generally has more habitat characteristics. A continuous forest offers transport routes for arboreal animals (animals that live in trees). ***"Crown cover"*** is the percent of the ground that has tree crown growing over it. A forest will have variable percentages of "holes" in the canopy. These "holes", or the amount of crown cover or crown closure, have important ecological ramifications.

Classical tropical humid rain forests probably have the most structure of any forest on Earth. Our north temperate forests are different. Not all forest types have a full complement of layering (understory, shrub, mid-size trees, main canopy trees, really tall trees). Jack pine stands, for instance, generally lack much vertical structure, especially with the kinds of soils they typically grow on. Northern hardwoods, if managed accordingly, will have a well-developed structure. Left unmanaged, they tend to lose structure close to the ground.

Heterogeneity and Forest Density

The level of ***"heterogeneity"*** refers to how similar or different the parts of a forest are to each other. Diversity is a big part of this, but so is structure and other forest descriptors. Heterogeneity might be evaluated within a single stand of trees, or be assessed across a large landscape, such as a national forest or the eastern Upper Peninsula.

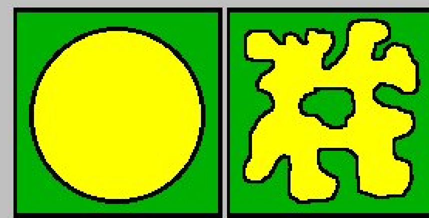
Basal area: is the cross-sectional area of a tree trunk at a point 4.5 feet from the ground, usually measured in units of square feet in the USA. Basal area per acre is the number of square feet per acre. Mature stands of trees in Michigan that are fully stocked usually have basal area values between 100 and 200 square feet per acre.

"Density" has to do with how many trees are in an area and how large the trees are. A thousand trees per acre may, or may not, be a lot of trees depending upon their size. A thousand seedlings are generally more than recommended, but the density is still low.

250 large, saw-timber sized trees per acres would likely be a high density forest. Density is typically measured in units of square feet and is called ***"basal area."***

Edge Effects

"Edge" refers to the transition zone between two different vegetation types. Some "edge zones" are sharp or narrow, such as the transition between a lake and the shoreline vegetation. Other transitions are more gradual, such as the change in forest composition up a slope in the Keweenaw Peninsula. These edge zones usually have representative species from both vegetation types, so they tend to be more diverse than either of the constituent types. Edge zones may also have species not found in either constituent type. In terms of broad-brush diversity, forest edge is a good thing, especially if higher numbers of species were the only measure.



The design of a timber harvest can have significant on habitat quality. Within a given area, more or less "edge" can be created according to the management objectives of the forest stand.

The downside of forest edge is the affect on species that prefer or require "deep woods" conditions. The introduction of edge to a "deep woods" type forest will stress those species that don't benefit from edge effects. The ovenbird is often cited as an example of an animal that can only be found in undisturbed, mature forests. This conclusion is arguable, as ovenbirds can often be heard in other forest types. What the ovenbird really needs is protection from ground predators, as they build their nests on the ground. Deep, dark forests tend to have fewer species and do not support high numbers of large predators.

Islands and Fragmentation

The process of changing a large forested area into an area of forest patches is called ***"fragmentation"***. These forest patches are referred to as ***"islands."*** The fragmentation of forest has important ecological impacts. These impacts are not necessarily "good" or "bad" but they are definable, at least in part.

Forest fragmentation is the land use change from forest cover to a non-forest cover. This is represented in the above image starting from the upper left and moving clockwise.

Forest fragmentation should not be confused with forest ***"parcelization"***. Parcelization is an ownership phenomenon that often, but not always, translates into forest fragmentation. Parcelization has direct economic impacts, as well as potentially direct ecological impacts.

Mathematical theories relating biological diversity and fragmentation were promulgated by a man named E.O. Wilson. These theories were developed to explain ecological trends and patterns found among the islands of the South Pacific. The theory is called "island biogeography". Both the original theory and its subsequent application to continental situations remain highly controversial.

Dead Trees and Snags

Dead trees, both on the ground and standing, provide habitat elements for many species, particularly cavity nesters. Dead wood also provided habitat for a number of insects which, in turn, are important parts of some food chains. A standing dead tree is called a ***"snag"***. Large snags and fallen trees have more value than small ones.

"Snag management" means producing more snags in a forest where snags are uncommon. From a strict timber perspective, snags are trees that could have been merchantable had timber been the only management goal and management implementation was perfect. As a legacy of our forest history, many of our forests remain in younger, more vigorous age classes. Snags become increasingly common as forests grow older. Forests of short-lived species already display an abundance of snags. The presence of snags in longer-lived forests can sometimes be accelerated through management. Snags in short-lived forests are usually retained during timber harvest.

Micro-Environments

Small areas within a forest environment that have markedly different characteristics are called ***"micro-environments"***. Examples might be rock outcrops, large rotting logs, pit-mound topography (tree tip-ups), springs and seeps, vernal (spring-time) ponds, or other features. These micro-environments sometimes harbor special sets of species, occasionally endangered or threatened species. Seeds of some tree species may depend on micro-climates / micro-environments to enhance their reproduction success. Manipulation of the forest canopy through management practices alters micro-environmental conditions such as light, temperature, and humidity.

Appearance

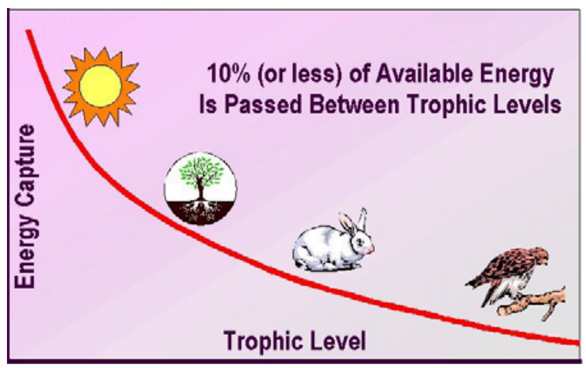
The ***"appearance"*** of a forest is not really an ecological factor, but it has great influence on how forests are managed or not managed. Forest management or lack of management can have significant ecological impact. The appearance of a forest strongly influences public opinion and public policy of the "goodness" or "badness" of a particular forest practice. An entire of compendium of "pseudo-science" has been developed to support what is essentially an argument against forest practices resulting in poor appearance. Generally, balanced ecological and biological information is not considered. This phenomenon is not unique to natural resources, of course.

"Visual quality" is the term often used as an objective in forest management. ***"Aesthetics"*** is a misnomer that is also quite common. An aesthetic involves the appreciation of something. Appreciation has deeper meaning than mere visual appearance. A well-done and properly applied clearcut can have high aesthetic value, but rather low visual quality.

FUNCTION

The ***"function"*** part of an ecosystem involves *"how"* things happen. It's equivalent to *"economics"* in our human society, or the themes of geography that involve the movement of goods and interactions between humans and the environment. How ecosystem functions are played-out can be highly complex, but the functions themselves are fairly easy concepts to understand. These areas of forest ecology are probably the least understood, but the most resilient. In addition to forest succession, described earlier, the following functions are important in forest ecology.

Energy Capture & Trophics



Nearly all life on Earth is solar-driven. Plants capture solar energy and store it as chemical energy (photosynthesis). Animals eat plants to obtain this stored energy, among other things. Some animals eat other animals, for the same reasons. These threads of energy transfer are called ***"food chains"***. Energy can be likened to the currency that measures an ecosystem economy. Life bucks the laws of entropy. In this sense . . . life is not "natural", but eventually all the energy is dispersed. The ***"rule of 10 percent"*** says that only 10 percent of the energy in each transfer is actually captured. So, plants only capture about 10 percent of the solar energy available to them. Herbivores capture only 10 percent of the energy stored in plants. And, the same is true "on down the line" of the food chain. Energy transfers occur between ***"trophic levels."***

Mineral & Nutrient Cycling

In addition to energy, a host of minerals and nutrients cycle through the biota. Understanding these cycles involves chemistry, biology, and physical geography. The most common elements are carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, and magnesium. A jingle to help remember these nine elements is "**CHOPKNS CaFe Mg**" or "**see Hopkins Cafe, might good**". There are another couple dozen or so elements needed, too.

How minerals and nutrients cycle through the biota varies considerably. Decomposers, soil type, water, and climate are determining factors. Cycles tend to be "open" in temperate zones, meaning nutrients are commonly lost to a system or a food web. A significant portion of available nutrients are found in ***"organic matter"***, or the layer of dead material on top of the soil surface. Tropical humid systems tend to be "closed" with very few nutrients slipping out of the system. Soils in these regions have very little organic matter.

The availability of a nutrient differs from the amount of a nutrient in the environment. For example, just because there is a lot of nitrogen in the atmosphere and the soil, doesn't mean it is in the form a plant can absorb. Nutrient availability varies with soil type, pH, and other factors. For more information about mineral & nutrient cycling, refer to the “Cycles” chapter.

Weathering

New minerals and nutrients are added to an ecosystem as rocks and soils are chemically broken down by weather and biological factors. ***"Parent material"*** is the rock or mineral source(s) from which soils are derived. The productivity of a particular soil is highly dependent upon the parent material in the area. Parent material rich in key elements will produce soils that support higher levels of biomass. Weathering is the prime source of "new" minerals and nutrients in an ecosystem.

Water Movement

The ***"hydrologic cycle"*** is commonly taught throughout Michigan at the upper elementary and middle school level. The amount of water on the Earth is a fairly finite quantity. Where it occurs and how it cycles has a tremendous impact on the biota in an area.

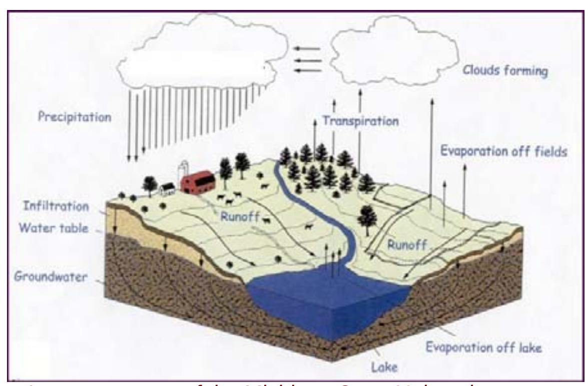


Image courtesy of the Michigan State University Institute of Water Research/Center for Remote Sensing

Essentially, water cycles through the atmosphere, living matter, and the soil. Movement can be "stalled" by a number of features, such as lakes, underground aquifers, glaciers, etc. As water moves downward through soils, it usually takes soluble nutrients with it. Water movement is the main reason for the "loss" of nutrients in an ecosystem.

Like nutrients, water availability to plants also varies. Coarse soils, those with relatively large particle size and pore size, tend to hold less water. They are drought-prone and most tree species don't grow well on these soil types. Finer soils, such as silts and clays, have very fine particles and hold more water. However, during dry periods, they may just as droughty as coarse (or sandy) soils because the drier these soils become, the tighter that water molecules "cling" to the soil particles. This cohesive property may be stronger than a root system's ability to pull the water molecules out of the soil.

For more information about the hydrologic cycle, refer to the “Cycles” chapter.

Temperature & Humidity

Temperature and humidity play important roles in the transfer of materials throughout an ecosystem. They also have strong influences on "who grows where" and affect metabolic processes of both plants and animals.

Photosynthetic rates correlate to temperature. Higher temperatures increase rates, to a certain point, after which a plant can "burn out". Very arid environments cause plants to close their pores in order to conserve water. Less water inside the plants can slow photosynthesis to a crawl. Desert plants have special adaptations for dry conditions. So do many plants in our northern bogs and sandy outwash plains. And the temperature-humidity condition immediately above a forest canopy on a hot summer day can be every bit as hostile as that in a desert.

Successful germination of tree seeds and early seedling survival are quite sensitive to temperature and humidity conditions on the forest floor. For example, sugar maple seeds germinate in the spring, soon after snow melt, when the temperature is 34 degrees (F). If an early spring heat wave hits, germination for that year will be poor. On the other hand, yellow birch, a common associate of sugar maple, germinates best around 74 degrees. That's part of the reason why an unmanaged northern hardwood stand will often migrate towards a sugar maple monotype and a managed northern hardwood stand will encourage the regeneration of other northern hardwood tree species.

TREE SPECIES DIVERSITY IN MICHIGAN FORESTS

There are many ways to categorize differences within the forest. One of the more commonly used classifications is that implemented by the U.S. Forest Service in their Forest Inventory and Analysis Unit (FIA). In Michigan, there are 15 forest types labeled according to their dominate tree species.

Acreage and Number of Tree Species Recorded in the Forest Types of Michigan

Forest Type	Acres	#Species	Forest Type	Acres	#Species
Northern Hardwoods	7,161	71	White Pine	234	32
Oak-Hickory	1,982	63	Scotch Pine	147	32
Elm-Ash Cottonwood	1,627	57	Balm-of-Gilead	190	27
Aspen	2,676	50	Jack Pine	846	26
Red Pine	897	40	White Spruce	147	25
Northern White Cedar	1,349	36	Black Spruce	465	22
Paper Birch	292	35	Tamarack	149	22
Balsam Fir	563	32			

Source: FIA data, 1992

Species diversity varies naturally between forest types. Human influence has also impacted species diversity. Tree species diversity may, or may not, reflect the diversity of plant forms, but might serve well as a preliminary indicator. Lastly, the FIA figures are for each forest type on a statewide basis. Every stand of trees belonging to a particular forest type will not display the same level of diversity as other stands within the forest type. Geography, stand history, soils, water, and other factors create variability within a particular forest type.

The forest type with the highest **number of tree species** is the northern hardwoods, typified by maple, basswood, beech, and yellow birch. Seventy-one tree species have been recorded within northern hardwood stands across Michigan. It is the most common forest type in Michigan and continues to become more common as time passes. The northern hardwood type is generally at the later stages of *forest succession*.

The forest types with the least number of tree species is tamarack and black spruce. These stands tend to be highly dominated by either tamarack or black spruce, with 21 other species occurring. These stands typically grow on wetland sites where fewer tree species can survive. However, these two species grow in many different forest types, as we'll examine further down this page.

The simple number of tree species is only one way of looking at diversity. The idea of "**species richness**" is important, too. Richness has to do with how dominant a few species are. For example, two stands may each have 1,000 trees of 25 tree species. In one stand, each species may have an equal number of trees, or 40 trees per species. This would be a species "rich" stand. The second stand may have 5 species that have 100 trees each, and the remaining 20 species have only 25 trees each. This stand would less "rich".

If we look at Michigan's 15 forest types using a tree species richness measure, the most diverse forest type is swamp hardwoods (elm-ash-cottonwood). The least diverse type would be jack pine.

Yet another way to look at forest tree diversity is the **species distribution** across different forest types. For example, sugar maple, beech, and basswood are largely restricted to northern hardwood stands. They are seldom found in other forest types. On the other hand, most of the white spruce volume is *not* found in white spruce stands. The following table shows how much volume of a particular species is found within its "typical" forest type. Species with high percents may be good indicators of a single forest type. Species with low percents are not very good indicators, but have the ability to survive across a wide spectrum of site conditions and forest associates. This concept is commonly used to identify understory species, particularly wildflowers, that can be used to indicate certain site conditions and productivity. Wildflowers are frequently better indicators than trees.

Tree Species Richness in Michigan Forest Types

Forest Type	Five Most Common Tree Species	Percent Volume Top Five Species
Elm-Ash-Cottonwood	Red Maple, Silver Maple, Black Ash, Green Ash, Cedar	58
Northern Hardwoods	Sugar Maple, Red Maple, Basswood, Hemlock, Beech	64
Balsam Fir	Balsam Fir, White Spruce, Quaking Aspen, Cedar, Paper Birch	69
Paper Birch	Paper Birch, Red Maple, Quaking Aspen, Cedar, Balsam Fir	75
Aspen	Quaking Aspen, Bigtooth Aspen, Red Maple, Paper Birch, Balsam	75
Oak-Hickory	Fir	76
White Spruce	N.Red Oak, White Oak, Black Oak, Red Maple, Bigtooth Aspen	76
Black Spruce	White Spruce, Quaking Aspen, Paper Birch, Balsam Fir, White Pine	77
White Pine	Black Spruce, Tamarack, White Pine, Balsam Fir, Cedar	78
Scotch Pine	White Pine, Red Pine, Red Maple, Quaking Aspen, Paper Birch	81
Northern White	Scotch Pine, Red Pine, Black Cherry, White Pine, Balm-of-Gilead	82
Cedar	Cedar, Balsam Fir, Paper Birch, Red Maple, Black Spruce	86
Balm-of-Gilead	Balm-of-Gilead, Cedar, Balsam Fir, Quaking Aspen, Paper Birch	90
Red Pine	Red Pine, White Pine, Jack Pine, N.Red Oak, Red Maple	91
Tamarack	Tamarack, Cedar, Black Spruce, White Pine, Balsam Fir	93
Jack Pine	Jack Pine, Red Pine, N.Red Oak, White Pine, Quaking Aspen	

Source: FIA data, 1992

Forest Type Association Preferences for Common Michigan Tree Species

Species	Forest Type	Pct. of Volume in Forest Type	Species	Forest Type	Pct. of Volume in Forest Type
Sugar Maple	Northern Hardwoods	95	Red Maple	N. Hardwoods	61
Beech	Northern Hardwoods	95	Cottonwood	Swamp	60
Basswood	Northern Hardwoods	89	Bigtooth Aspen	Hardwoods	57
Hemlock	Northern Hardwoods	87	Green Ash	Aspen	56
Yellow Birch	Northern Hardwoods	85	Quaking Aspen	Swamp	55
Silver Maple	Swamp Hardwoods	83	Black Ash	Hardwoods	54
Red Pine	Red Pine	79	Black Spruce	Aspen	46
Black Oak	Oak-Hickory	78	Tamarack	Swamp	34
White Oak	Oak-Hickory	77	Balm-of-Gilead	Hardwoods	32
White Ash	Northern Hardwoods	76	American Elm	Black Spruce	31
Jack Pine	Jack Pine	73	White Pine	Tamarack	27
Black Cherry	Northern Hardwoods	71	Paper Birch	Balm-of-Gilead	23
Cedar	Cedar	70	Balsam Fir	Swamp	23
N.Red Oak	Oak-Hickory	65	White Spruce	Hardwoods	15
Scotch Pine	Scotch Pine	65		White Pine	
				Paper Birch	
				Balsam Fir	
				White Spruce	

Source: FIA data, 1992, for tree species with at least 100,000 cubic of volume in Michigan.