Forest for the Trees

(Community Structure and Succession)

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NGSS Middle School Performance Expectations

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Objectives

Upon completion of this lesson students will be able to:

1. Describe community structure using terms such as species composition, species abundance, physical structure, and dominant species.
2. Define succession as a change in community structure over time.
3. Explain the role of disturbance in succession.
4. Describe how the age, height, and shade-tolerance of tree species influence the succession of a forest community.
5. Define climax as a mature community that remains relatively unchanged over time, in the absence of a major disturbance.
6. Distinguish between primary and secondary succession.

Materials and Setup

Engage:

Arrange students in groups of three. Materials required for this portion of the lesson are listed below (masters attached).

- community profiles (Forests A, B, and C) – one copy of each per group
- community profile transparencies (Forests A, B, and C) – one copy of each for teacher
- tree species key – one per group
- tree species key transparency – one for teacher

Explore:
Additional materials required for this portion of the lesson are listed below (masters attached).

- community structure worksheet – one per group
- community structure worksheet transparency – one for teacher
- forest layers transparencies – one per group and one for teacher
- basal area diagrams (Forests A, B, and C) – one copy of each per group
- basal area diagram transparency (Forest A) – one for teacher
- basal area worksheets (Forests A, B, and C) – one copy of each per group
- basal area worksheet transparency (Forest A) – one for teacher
- cm-rulers – one for each student
- blank transparencies and wet erase markers – one of each per group
- terms written on the board in the following format

COMMUNITY STRUCTURE

species composition *physical structure*
species abundance *dominant species*

Explain:
No additional materials required for this portion of the lesson.

- terms written on the board in the following format

SUCCESSION

disturbance *primary succession*
shade-tolerance *secondary succession*
climax

Elaborate:
Additional materials required for this portion of the lesson are listed below (masters attached). Tree field guides must be assembled before the lesson by cutting each page along the dotted line and stapling half-pages together, forming a booklet.

- tree field guides – one copy per group
- tree ranking worksheets – one copy per group
- tree ranking worksheet transparency – one copy for teacher

Evaluate:
Formally assess student understanding (quiz and key attached).

Safety
This lesson poses no specific safety hadzards.

Requisite Knowledge/Skills for Students
Students should be comfortable with the concepts of species and population. They should also understand that a community is an assemblage of populations of different species interacting in a particular location. If students investigate basal area in *Activity 2* of the Explore, they should be comfortable using the formula for area of a circle.

Procedure

<u>Engage</u>:

15-20 minutes. Students will examine three community profiles (Forests A, B, and C), images depicting lateral views of forest communities. Students will use their observations about each forest to discuss whether they think the profiles represent one, two, or three different forests.

1. Break students into groups of three and pass out the community profiles (Forests A, B, and C) and tree species key to each group. Tell students that today they will act as scientists, investigating forest communities, by looking at diagrams designed to represent natural forests. Point out that this will allow them to simulate what forest scientists do without leaving the classroom. Tell students the profiles show a side view of three forests, each consisting of several populations of various tree species. Use a transparency of the tree species key to introduce each species, drawing attention to their different shades and shapes. Have students begin their investigation by making observations about each of the forest communities. Ask them if they believe the three profiles portray the same or different forests, and why. Remind students that, as scientists, they should look closely at the three profiles and base their conclusions on evidence. If students are slow to respond, encourage them to compare and contrast the forests. Refer to transparencies of each profile while students share and discuss observations to clarify their reasoning for the rest of the class.
2. *Evaluate*: There may be a difference of opinion among students about whether the profiles represent the same or different forests. Regardless of their view, student reasoning should be based on specific observations. For example, students may argue that the three forests are different because the trees are bigger or smaller in one community relative to another. Or they may point out that aspen is present in Forests A and B, but absent from Forest C. This may lead students to suggest that two of the forests are essentially the same and differ from the third. Make sure students' conclusions are evidence-based, that they reference specific observations of the profiles to support their reasoning.
3. Highlight student observations by writing them on the board. Refer to these later in the Explore when new ecological terms (community structure, species composition, species abundance, physical structure, and dominant species) are introduced. For example, students will learn in the Explore that "species abundance" is the term for how many trees of a particular species are found in a forest community. They may observe that the species abundance of aspen in Forest B is higher than in Forest A. Suggest to students that, before the class can conclude whether or not the profiles represent the same or different forests, they need to know how scientists describe communities and that they will explore this next.

Explore:
60-90 minutes. Students will carefully examine the community profiles (Forests A, B, and C) to explore various components of community structure. They will emulate forest ecologists, by collecting and analyzing data to develop an understanding of community structure and begin to contemplate the concept of succession.

Activity 1

1. Throughout this portion of the lesson, play devil's advocate with students. Playfully get them to reconsider their conclusions about how many different forests are represented by the three profiles. Do this by emphasizing students' observations and encouraging them to evaluate the evidence, persuading them one way and then the other. Remind them that scientists reach conclusions based on evidence.
2. Inform students that a forest, like all communities, has a structure consisting of several different components. Forest ecologists are scientists who study *community structure*. Direct students to the term written on the board. Tell students to act as forest ecologists by re-examining the profiles, and ask them which species are present in each of the forests. Have them complete the "species composition" portion of the community structure worksheet by placing an "X" next to the species that are present in each forest. When finished, ask students if all five tree species are present in each community. They should respond that the forests are composed of basically the same trees; only Forest C is lacking one of the five species, aspen. This discovery may lead students to think that the forests are actually the same. Use student observations of the profiles to introduce *species composition* as a characteristic of community structure. Define it as the variety of species making up a community, directing them to the term on the board.
3. Point out that species composition is only one aspect of community structure, and now they will investigate another. Ask students what the most common species are in each forest. Have them complete the "species abundance" portion of the community structure worksheet by recording how many individual trees of each species are found in the three forests. Students should see that beech and maple are the most common species in all three forests, along with aspen and oak in Forest B. As a result, some students may conclude that all three forests are the same. Others may argue that the large number of aspen trees in Forest B makes this community distinctly different from Forests A and C. Remember to play devil's advocate, emphasizing the similarities or differences among the three forests. Introduce the concept of *species abundance* as another component of community structure. Define it as the quantity of a particular species present in a community, directing students to the term on the board. Point out how measuring the abundance of each species provides more information than simply recording whether a species is present. For example, aspen is present in Forests A and B (species composition), but is more prevalent in Forest B (species abundance).

4. Introduce the vertical layers in a forest using a forest layers transparency positioned over a transparency of Forest A. Orient students by showing them how the canopy layer consists of trees taller than 15 meters and how the understory layer contains the rest of the trees below this height. Point out trees in each layer, showing students how to use the y-axis on the forest layers transparency to estimate tree height. It may be helpful to use the analogy of layers in a house (2nd floor and 1st floor). Prompt students to explore which species make up the canopy of each forest. Have them complete the "physical structure" portion of the community structure worksheet by recording the number of trees for each species that reach into the canopy layers of the three forests. Ask students which species make up the canopy in each community. Aspen is present in the canopy layers of Forests A and B. Beech and maple reach into the canopies of Forests A and C. Oak contributes to the canopy layers of all three forests. Use student responses to introduce *physical structure* as another characteristic of community structure. Define it as the vertical layers in a community, directing students to the term on the board. Point out that vertical layering among the trees of a forest provides a diversity of habitats for animals and other organisms. Again, ask if the profiles represent the same or different forests. After considering alternative answers, tell students there is an additional component of community structure that they should investigate before deciding.

5. *Evaluate*: Throughout this portion of the Explore, students should develop an understanding of community structure through the collection and analysis of data. Students should carefully examine each community and record their observations in a worksheet, using the results to take a stance on whether or not the profiles represent one or several forests. Regardless of their position, student conclusions should be based on evidence and supported by logical reasoning.

Activity 2

(Steps 1-3 of this activity are optional if grade level permits using the formula for area of a circle. If not, skip to step 4, omitting basal area from subsequent discussion.)

1. Tell students that they will continue to examine community structure the way forest ecologists do. Hand out the basal area diagrams for Forests A, B and C to each group. Explain to students that these images are another way to represent the forests in the community profiles (they are the same three forests). Tell them that each of the circles in the diagrams represents a tree in that particular forest. The diagrams show a view from above, looking down at the trees as if their trunks were cut in half and the tree tops removed. Use a transparency of the basal area diagram for Forest A to show how each shade or pattern corresponds to a given species of tree. For example, dogwood is represented by black circles, while striped circles indicate beech trees.

2. Tell students the biomass, or total amount of living tissue, of a species is another component of community structure. Explain that forest ecologists use basal area (the cross-sectional area of a tree trunk) as an estimate of biomass. Have students visualize cutting a tree trunk horizontally across at shoulder height, and to picture the resulting circle they would see looking at it from above. Since trunks are

roughly cylindrical, basal area can be calculated using the equation for the area of a circle (πr^2). Point out this equation and the one for calculating radius from diameter ($r = d/2$), using a transparency of the basal area worksheet for Forest A.

3. Have students begin collecting data. Using a transparency of the basal area diagram for Forest A, show students how they can measure the diameter of each tree (circle) with a cm-ruler. Tell them to measure each diameter in millimeters and to record their measurements on the basal area worksheet for the appropriate forest. Point out the millimeter-to-centimeter conversion for their measurements on the basal area diagrams: multiply millimeters by 2.5 to obtain tree diameters in centimeters. Remind students that the forest trees have much larger diameters than the circles in the diagrams. Their converted diameters (cm), however, represent the actual tree sizes. Have them calculate the total basal area (cm^2) for the species in each forest. These values should be recorded in the boxes labeled "Total" on the basal area worksheets. Caution students that they need to calculate the basal area of each individual tree of a species, before summing these values to obtain the total basal area for a species in a forest (work all the way across each row in a worksheet before adding up values in the total basal area column). Tell each individual in a group of three to calculate basal area for one of the three forests (A, B, or C) and share their results with group members. Have groups who finish early write their total basal area calculations for the species in each forest on the board. Remind students that scientists share their results so they can be verified by others. When all groups have finished, ask students which species have the largest basal area in each forest. They should respond that beech, maple, and oak do in Forest A, aspen and oak do in Forest B, and beech and maple do in Forest C.

4. Introduce *dominant species* as the largest and most common species in a community. Explain to students that dominant species have a relatively large impact on their community, directing them to the term on the board. With the largest species abundance, the dominant trees of a forest provide the majority of habitat for animals, such as birds and squirrels. With the largest total biomass (estimated by basal area), they store lots of nutrients in their tissues, releasing some in the fall when leaves drop to the forest floor and decompose. The dominant species also make up the bulk of the canopy, controlling the amount of light reaching plants in the understory layer.

5. *Evaluate*: Have students look again at their community profiles and various worksheets. Ask them which species are dominant in each forest and how they know. Students should give responses illustrating their understanding that the dominant species in a forest community are the largest and most abundant, comprising the bulk of the canopy layer and total biomass (basal area) of the forest. The species with the largest abundance and total basal area in Forest A are beech, maple, and oak, making them the dominant species. Aspen is present in the canopy layer, but only represented by two trees. Dogwood is relatively abundant, but doesn't contribute to the canopy. Beech, maple, oak, and aspen are all abundant in Forest B. However, aspen and oak have the largest total basal area and are the only species that reach into the canopy layer, making them the dominant species. Beech and maple are clearly the dominant species in Forest C.

These two species have the largest abundance and total basal area, making up the majority of the canopy. Ask students how these observations influence their opinions about whether the profiles represent one or several forests. Regardless of the position students take, make sure their conclusions are based on the results of data collection and analysis. When citing their evidence, encourage students to use relevant terms, such as community structure, species composition, species abundance, physical structure, and dominant species.

6. Have students focus on the community profile for Forest A. Ask them how the structure of this forest may be different in 100 years. Guide students to the realization that the understory only contains beech, maple, and dogwood by asking which trees are present in the layer. Point out that the trees currently in the understory may grow into the canopy in the future. Also discuss which trees will die in the near future (older trees currently in the canopy) and which tree species are reproducing (indicated by the smallest trees in the understory.) Have each group draw a new community profile on a blank transparency, illustrating what they think Forest A will look like in 100 years. Encourage them to consider the growth, death, and reproduction of the trees currently in Forest A when constructing their diagrams. While students are working, try to find a group drawing similar to the community profile for Forest C. When finished, ask this group to share their future profile with the class by placing it on an overhead. Ask the group to describe the trees in the canopy and understory layers, and how they differ from those in Forest A. Ask the class if the future profile looks familiar. They may realize that the diagram is similar to the profile for Forest C. If not, ask students if the diagram looks anything like the profile for Forest B (which it shouldn't). Then ask if it resembles Forest C, pointing out similarities in the canopy layers and abundance of species so students see they are the same forest. Students may point out that their drawings include aspen, while the profile for Forest C does not. Explain that aspen is a short-lived tree (doesn't live very long), which could account for its absence from Forest C. Also, the trees could have succumbed to disease or wind storms. Students may also point out that their drawings include taller dogwoods, possibly reaching into the canopy layer, while no dogwoods reach into the canopy of Forest C. Explain that various species of trees grow to different heights and that dogwood might not get big enough to contribute to the canopy layer in Forest C. Make sure students understand that communities change over time and that Forest C represents the future Forest A.

7. Ask students to imagine what Forest A looked like 100 years earlier. They should point out that it may have been similar to Forest B. If not, direct their attention to the profile for Forest B. Ask students if it is possible that Forest A looked similar 100 years earlier. If they answer "no," point out that the largest aspen trees in Forest B may have died, and that smaller beech, maple, oak, and aspen trees may have grown into the canopy layer in Forest A, along with the remaining larger oaks. They should begin to understand that the three profiles represent the same forest at different periods in time. Ask students, "once and for all," if forests A, B and C are the same or different forests. Have them arrange the profiles in order from youngest to oldest (B, A, C.) Tell students that they will explore how communities change over time in the next part of the lesson.

Explain:
20-30 minutes. Students will articulate their understanding of community structure and succession through class discussion and individual writing. They will also explore the role of disturbance in succession.

1. Define *succession* for students as a change in a community's structure over time, directing them to the term on the board. Ask students how community structure changed in the profiles from Forest B to C. Remind them to use the ecological terms they have learned and support their answers with specific observations from the profiles and various worksheets. Students may say that the trees grew taller, forming a thick, or closed, canopy layer. Ask them which term applies to this observation (*physical structure*). Or students may point out that aspen decreased in number, eventually disappearing from the forest. Highlight this as an example of how the *species composition* and *abundance* of particular species can change in a community over time. If students are slow to respond, direct them to the community structure worksheet and ask them how the species composition and abundance, and physical structure of the forest changed over time. Students may also note that beech and maple eventually took over the forest (*dominant species*), making up the majority of the canopy layer in the mature forest (C). Remind them that dominant species are the largest and most abundant, and have a relatively large impact on the rest of the community. Ask students what other measurement forest ecologists use to identify the dominant species in a community. They should recall that basal area estimates biomass and that dominant species have the largest total biomass in a community. Ask students if the dominant species of the forest changed over time. They should recognize that aspen and oak had the largest total basal area in the young forest (B), and beech and maple do in the mature forest. Inform students that all of these changes in a community's structure over time are succession. Remind them that trees provide habitat for animals and other organisms, and that changes in species composition, species abundance, and physical structure can impact the resident species of a forest. For example, birds often have preferred nesting sites, and different bird species can be found in a forest as it passes through various stages of succession.

2. Have students look at the profile of the mature forest and ask what could cause the community to once again look like it did as a young forest. Students may suggest that logging or fire could make the forest essentially start over. Introduce the concept of *disturbance* to students, directing them to the term on the board. Define it as an event that destroys or removes organisms in a community, such as fire, logging, or a severe wind storm. Explain that succession is the process that the community goes through following such a major disturbance.

3. *Evaluate:* Have each student write a paragraph or two describing the community structure of a forest. Remind them to use the ecological terms they have learned. Ask students to define succession and explain the role of disturbance in this process. Tell them to provide relevant examples from our fictitious forest to illustrate their understanding of community structure and succession.

Elaborate:
50-60 minutes. Students will investigate how the height, age, and shade-tolerance of different species affect the path of succession in a forest community.

Activity 1

1. Having begun to explore succession, tell students the next question is "why" the community structure of a forest changes over time. Explain that the success of any species is the result of a number of complex interactions and that their current classroom investigation can highlight a few of these factors. Point out that forest ecologists look at specific characteristics of trees in order to understand a forest community. Ask students if the tree species in our forest all grow to the same height. They should recognize that dogwood never reaches the canopy. Ask them if each of the species lives to the same age. They may guess that beech, maple, and oak outlive aspen trees in the canopy of the middle-aged forest (A), explaining the absence of aspen in the mature forest (C). If not, suggest this. Ask students what they think happens to the amount of sunlight reaching the understory as trees grow into the canopy layer and thicken over time. They should be able to predict that it decreases as the canopy closes. Explain that younger trees in the understory often struggle to get enough light to survive. Introduce the ability of trees to withstand low light levels as *shade-tolerance*, directing students to the term on the board. Tell them that before they can understand how these factors interact to affect succession, they need to explore the specific characteristics of each species in the tree field guide. Use a transparency of the tree ranking worksheet to show students how to record the name of each species on the worksheet, according to its height, age, and shade-tolerance.
2. After students complete the tree ranking worksheet, direct their attention back to the community profiles. Tell them to use the information they found in the tree field guide to answer the next several questions. Ask students why dogwood never reaches the canopy layer. They should respond that the tree has a maximum height of 10 meters. Ask why aspen is absent from the mature forest. The explanation for this is more complicated, but students may suggest that the maximum age of the tree is 60 years and simply does not persist. Another factor impacting the loss of aspen from the forest over time is that the species is shade-intolerant. As the canopy closes, light levels decrease in the understory to the point that aspen trees cannot survive, and thus, do not regenerate themselves in the forest. Remind students that the mature forest is dominated by beech and maple, but that a large remnant oak is also present in the canopy layer. Ask why oak is not more prevalent in the mature forest (it grows as tall and lives as long as beech and maple). Help students to recognize that oak is not as shade-tolerant as beech or maple, and thus, is less abundant.
3. Have students re-examine the profile for the mature forest. Describe the community for them as a mature beech-maple forest. Ask them what the forest is likely to look like in 100 years. Ask which species will grow from the understory layer into the canopy. Ask which species are reproducing, and thus, will be able to replenish themselves in the forest. Remind students that this is determined by which species are producing young trees. They should recognize that beech,

maple, and dogwood are all reproducing, but that only beech and maple will grow into the canopy and continue to dominate the community. The future forest should look very similar to the way it does now. Introduce *climax* as a mature community that remains relatively unchanged over time in the absence of a major disturbance. Direct their attention to the term on the board. Explain that the dominant species, beech and maple, are able to regenerate themselves indefinitely, because of their ability to tolerate low light levels in the understory.

4. *Evaluate*: Have students add to their paragraph from the Explain. Ask them to describe how height, age, and shade-tolerance affect the path of succession in a forest community. Ask them to define a climax community.

Activity 2

1. As an optional extension to the lesson, have students investigate dune succession on the western shore of Lake Michigan. There are many different types of sand dunes that develop and change over time, due to some sort of disturbance. In general, the stages of dune succession in Michigan include a shift from sandy beaches, to dune grasses, to low-growing evergreen shrubs, to scattered trees, to forests. The succession of a parabolic dune begins with the blowout of a forested region along the lakeshore. This wind-borne disturbance has a major impact on the community, including a loss of soil as well as trees and other species. Because the community must essentially start over, forming a new soil layer and accumulating colonizing species from neighboring areas, it is an example of *primary succession*. Unlike the impact of disturbance in dune succession, the soil layer of a forest following logging or fire remains intact, serving as an example of *secondary succession*. Visit a parabolic dune at Hoffmaster State Park (http://www.michigandnr.com/parksandtrails/ParksandTrailsInfo.aspx?id=457) or Rosy Mound (http://www.miottawa.org/ParksVI/Parks/rosymound.htm), which clearly model the role of disturbance and the stages of dune succession that follow.

Evaluate:
During the Engage (*Observation of Community Profiles*): Students compare the three community profiles and use their observations about each forest to take a stance on whether they think the profiles represent one, two, or three different forests. Student responses should include specific observations of the profiles, possibly about the heights or relative abundance of the tree species in each forest. Regardless of their opinions about whether the profiles represent one or several forests, student conclusions should be based on evidence and supported by logical reasoning.

During the Explore (*Community Structure and Basal Area Worksheets*): Students collect and analyze data from the community profiles and basal area diagrams to develop an understanding of community structure (Objective 1) and support a conclusion about whether the profiles represent one or several forests. They should be able to correctly use ecological terms such as species composition, species abundance, physical structure, and dominant species in discussion.

After the Explain (*Written Paragraph*): Students construct a paragraph or two describing community structure (Objective 1), defining succession (Objective 2), and explaining the role of disturbance in the process (Objective 3). Students should be able to define succession as a change in community structure over time, including changes in species composition and abundance, physical structure, and dominant species. They should also be able to describe how these successional changes follow some disturbance in a community.

During the Elaborate (*Tree Ranking Worksheet*): Students collect and analyze data from the tree field guide to understand how the height, age, and shade-tolerance of species influence the succession of a community (Objective 4). Students add to their paragraph from the Explain, describing how these factors affect the path of succession in a forest and define climax as a mature community that remains relatively unchanged over time, in the absence of a major disturbance (Objective 5).

After the Elaborate (*Quiz*): The quiz formally assesses students' understanding of community structure and succession (Objectives 1-2), including the role of disturbance (Objective 3), factors that influence forest succession (Objective 4), and the concept of climax (Objective 5). It also evaluates students' understanding of the difference between primary and secondary succession (Objective 6).

Scientific Background for the Teacher

In general, a community is an assemblage of populations of different species interacting in a particular location, including various forms of predation, competition, and mutualism. Succession describes the many types of changes a community goes through over time, including changes in resident species as well as the physical environment. These changes, in turn, impact the complex interactions of the members of a community. Successional changes are often initiated by some kind of disturbance to a community, such as fire or logging, which destroys or removes organisms.

This lesson focuses on community structure and succession, specifically the changes that occur among the tree species and the overall appearance of a forest over time. This includes changes in species composition and abundance, or the particular types of trees and their relative prevalence in a forest. It also includes changes in the physical structure, or vertical layering (canopy layer, understory layer, etc.), and dominant species in a forest. Dominant species are the largest and most common species in a plant community and can exert a relatively large impact on the rest of the community by affecting environmental conditions. The physical structure of a forest influences the diversity of habitats available for wildlife, with trees providing many resources such as food, nest sites, or general habitat, providing shade, blocking wind, etc. Through succession, changes in the tree species composition and physical structure of a forest impact other plant species and resident animal species. For example, only some plants can grow on the forest floor of a mature forest whose canopy has reduced the amount of light available for photosynthesis; and birds or squirrels may have preferred habitats or nest-tree species.

As a young forest matures, the particular changes in community structure are the result of a number of factors. This lesson focuses on the roles of height, age, and shade-tolerance of tree species in succession. Long-lived tree species that grow large play a prominent role in the structure of a forest community, impacting environmental conditions for long periods of time. However, tree species have different levels of tolerance for the low light conditions under a closing canopy layer of mature trees. The shade-tolerance of a species describes its ability to survive diminished light levels and affects the future composition of a forest by determining which species will be able to regenerate themselves indefinitely. Tree species that cannot tolerate low light levels will not regenerate and will eventually fail to contribute to the species composition of a forest. Climax describes a mature plant community that remains relatively unchanged over time in the absence of a major disturbance.

Because the soil layer of a forest following fire, logging, or farm abandonment remains relatively intact, this lesson illustrates one type of succession, secondary succession. In primary succession a community must essentially start over, forming a new soil layer and accumulating colonizing species from other nearby communities. Glaciation, volcanic islands, and dune succession are all examples of primary succession and generally take longer for a community to establish.

This lesson uses a common Michigan forest type (beech-sugar maple) to explore the concepts of community structure and succession. We recommend using the lesson as a primer for students before any ecological investigation outside the classroom, as a way to help students see the "forest for the trees."

Misconceptions

Students may have a preconceived belief that communities change little over time (D'Avanzo 2003). This lesson addresses the misconception by helping students understand succession, factors that influence specific outcomes, and the role of disturbance in initiating the process.

Interdisciplinary Components

This lesson incorporates using the formula for the area of a circle to solve problems. Although not the primary focus of the lesson, this math concept is addressed in supporting the development of characteristics of community structure. Specifically, basal area (cross-sectional area of trees) is used to estimate the biomass of different species, as a measure of dominance in a community.

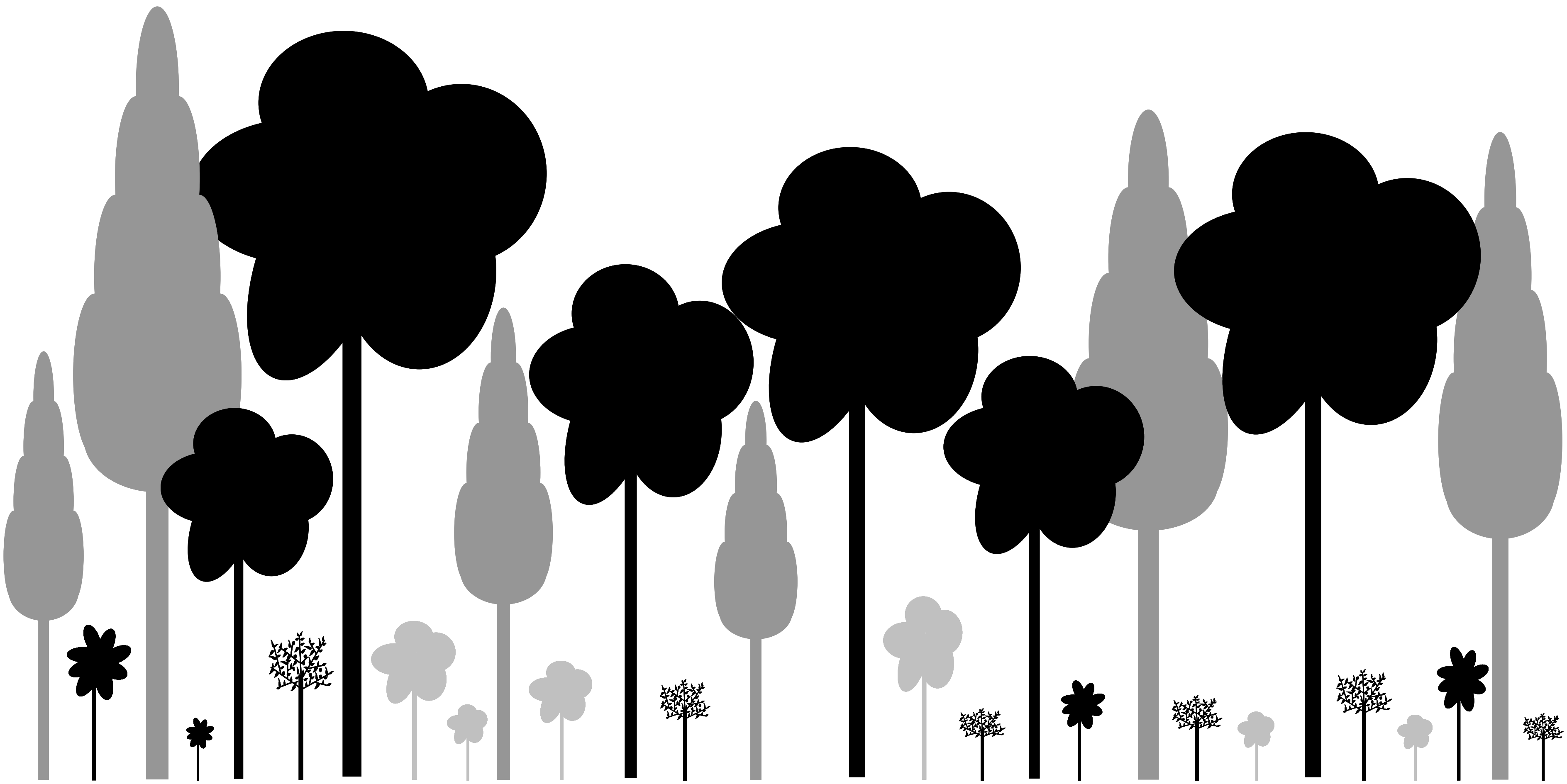
References

Barnes, B. and W. Wagner, Jr. 1981. *Michigan Trees: A Guide to the Trees of the Great Lakes Region*. Ann Arbor, MI: The University of Michigan Press.

D'Avanzo C. 2003. Application of research on learning to college teaching: Ecological examples. *Bioscience*, 53(11):1121-1128.

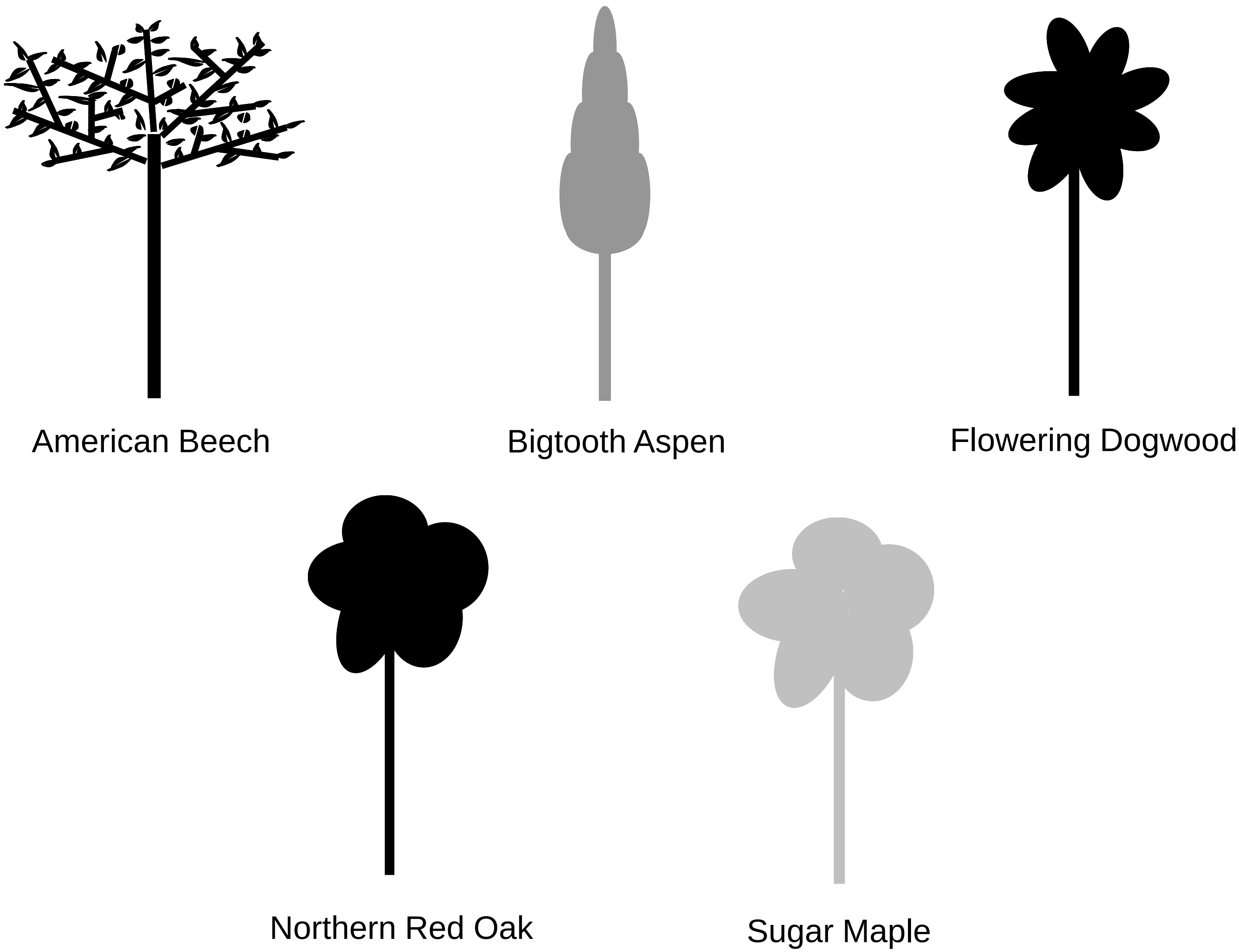
Community
Profile (Forest A)

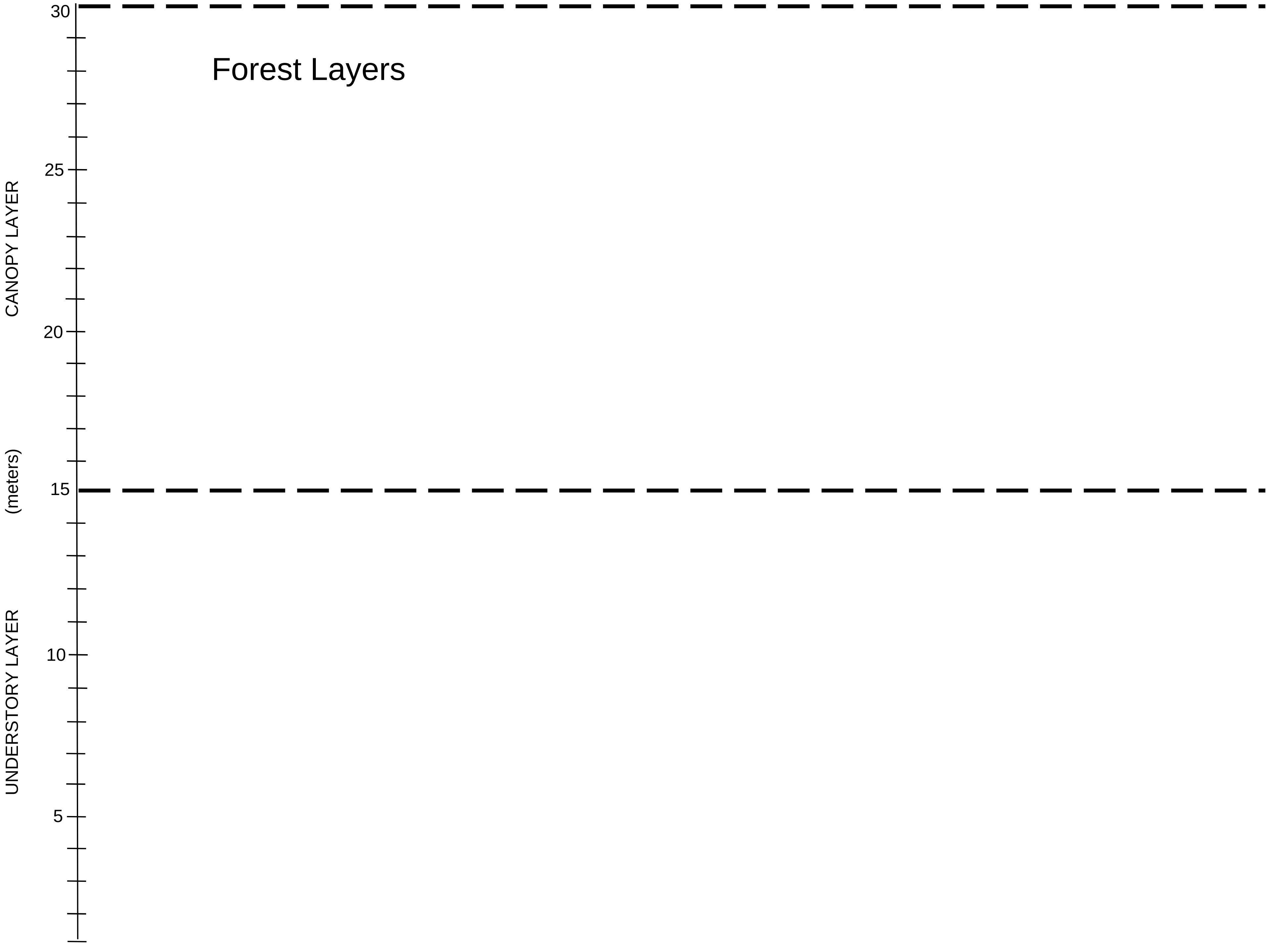
Community Profile
(Forest B)




Community
Profile (Forest C)

Tree Species Key




Forest Layers
CANOPY LAYER
(meters)
UNDERSTORY LAYER
30
25
20
15
10
5

Community Structure Worksheet

Species Composition

Directions: Place an “X” in the box if a species is present in Forest A, B, or C.

	Forest A	Forest B	Forest C
American Beech			
Bigtooth Aspen			
Flowering Dogwood			
Northern Red Oak			
Sugar Maple			

Species Abundance

Directions: Record the number of trees for each species that exists in Forest A, B, and C.

	Forest A	Forest B	Forest C
American Beech			
Bigtooth Aspen			
Flowering Dogwood			
Northern Red Oak			
Sugar Maple			

Physical Structure

Directions: Record the number of trees for each species in the canopy layer of each forest.

	Forest A	Forest B	Forest C
American Beech			
Bigtooth Aspen			
Flowering Dogwood			
Northern Red Oak			
Sugar Maple			

Community Structure Worksheet (Key)

Species Composition

Directions: Place an “X” in the box if a species is present in Forest A, B, or C.

	Forest A	Forest B	Forest C
American Beech	X	X	X
Bigtooth Aspen	X	X	
Flowering Dogwood	X	X	X
Northern Red Oak	X	X	X
Sugar Maple	X	X	X

Species Abundance

Directions: Record the number of trees for each species that exists in Forest A, B, and C.

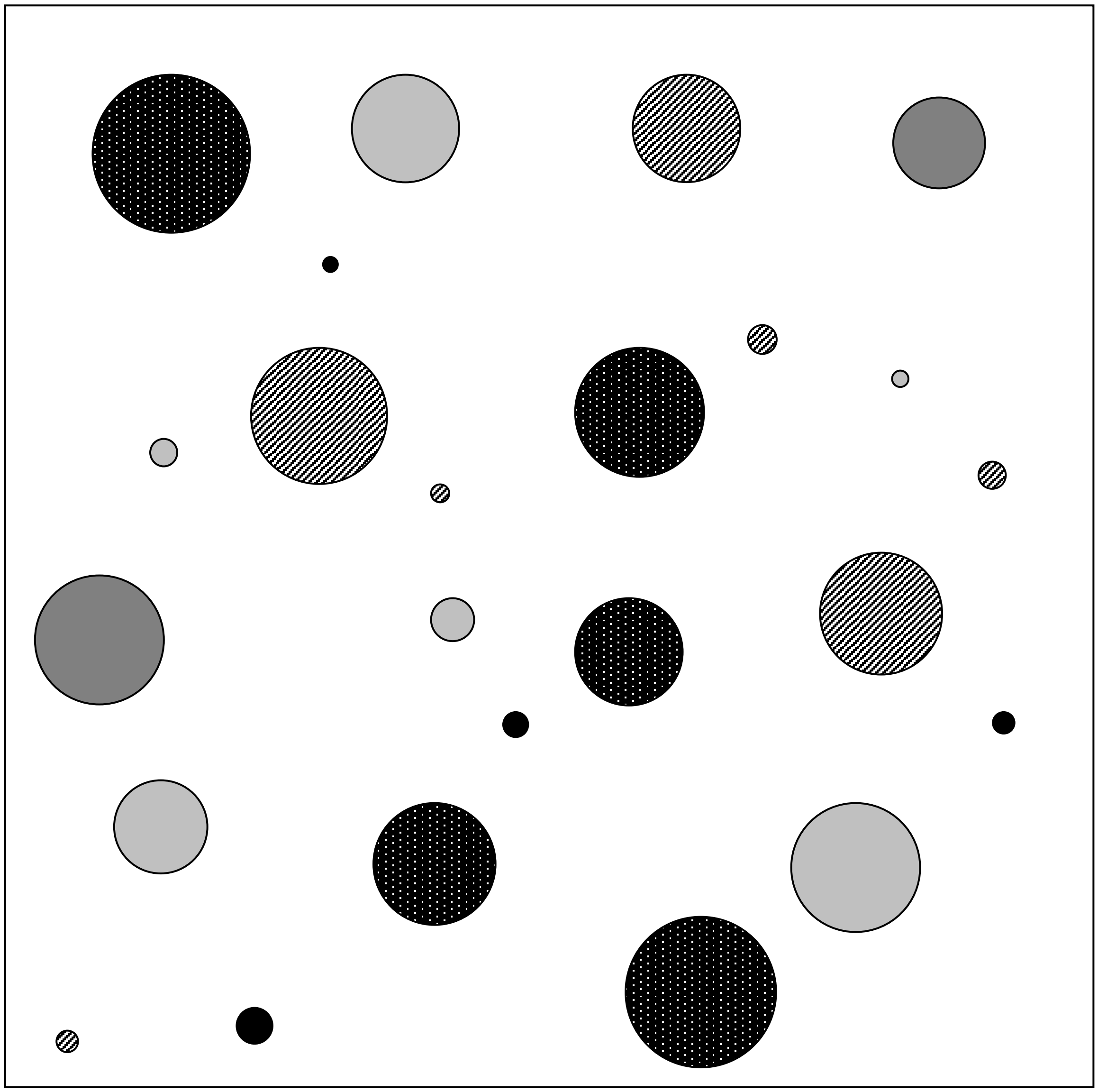
	Forest A	Forest B	Forest C
American Beech	7	6	7
Bigtooth Aspen	2	6	0
Flowering Dogwood	4	4	4
Northern Red Oak	5	6	1
Sugar Maple	6	6	8

Physical Structure

Directions: Record the number of trees for each species in the canopy layer of each forest.

	Forest A	Forest B	Forest C
American Beech	3	0	5
Bigtooth Aspen	2	3	0
Flowering Dogwood	0	0	0
Northern Red Oak	5	3	1
Sugar Maple	3	0	5

Basal Area Diagram
(Forest A)



Scale: 1mm = 2.5cm

American Beech

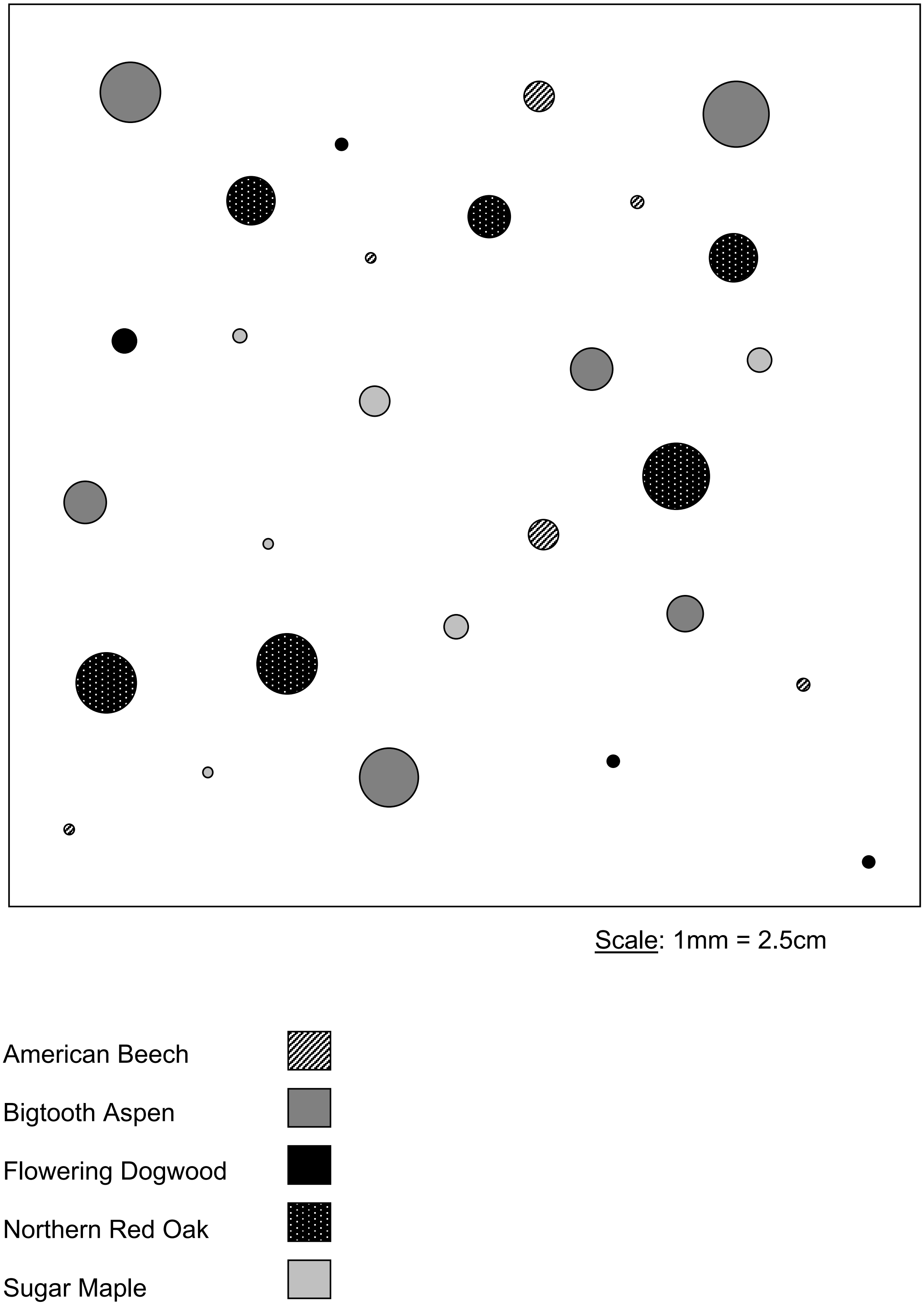
Bigtooth Aspen

Flowering Dogwood

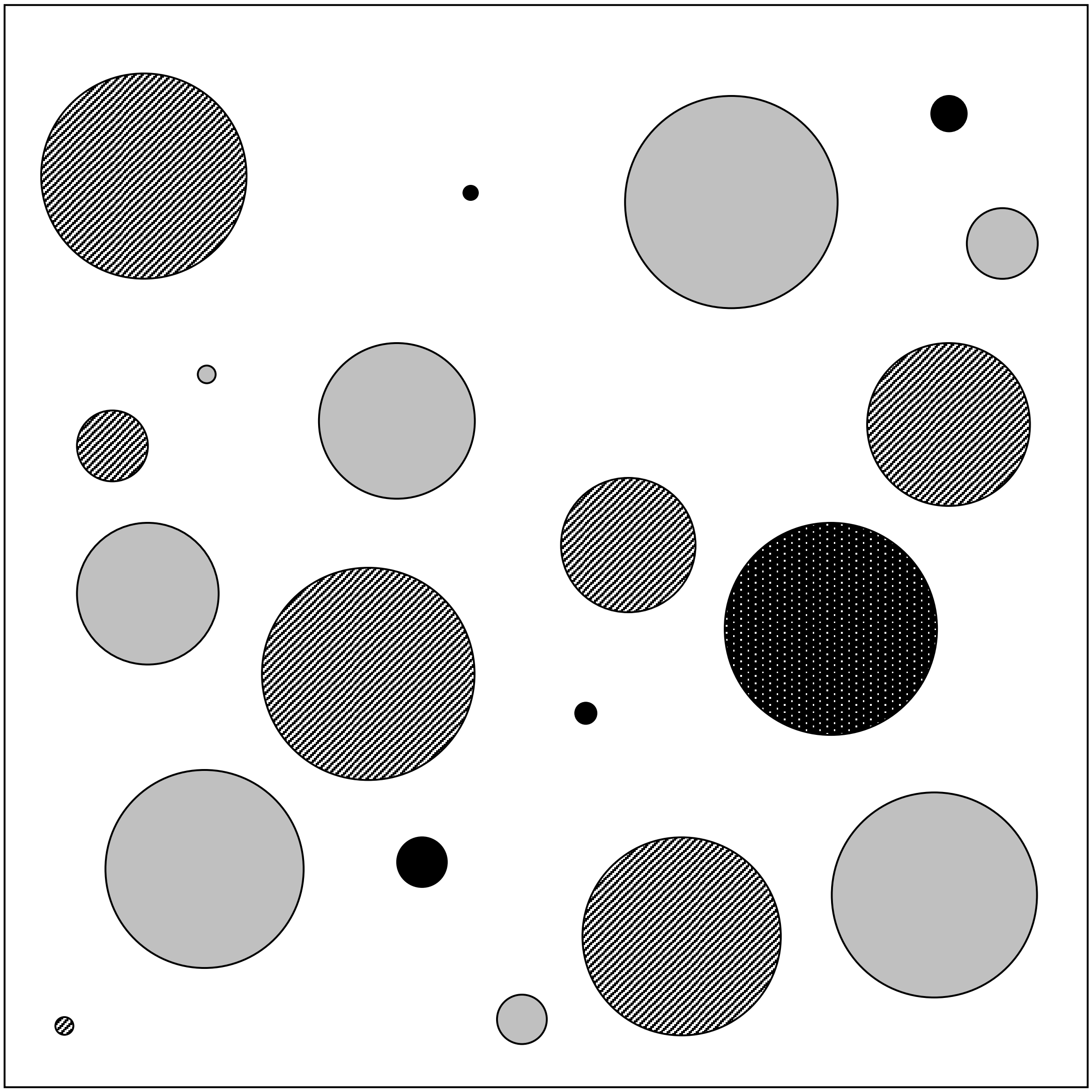
Northern Red Oak

Sugar Maple

Basal Area Diagram
(Forest B)



Basal Area Diagram
(Forest C)



<u>Scale</u>: 1mm = 2.5cm

American Beech

Bigtooth Aspen

Flowering Dogwood

Northern Red Oak

Sugar Maple

Basal Area Worksheet
(Forest A)

American Beech

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Bigtooth Aspen

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Flowering Dogwood

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Northern Red Oak

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Sugar Maple

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Basal Area Worksheet
(Forest B)

American Beech

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Bigtooth Aspen

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Flowering Dogwood

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Northern Red Oak

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Sugar Maple

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Basal Area Worksheet
(Forest C)

American Beech

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Bigtooth Aspen

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Flowering Dogwood

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Northern Red Oak

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Sugar Maple

	Diameter Measurement (mm)	Diameter Conversion (cm)	Radius $r=d/2$ (cm)	Basal Area πr^2 (cm^2)
1				
2				
3				
4				
5				
6				
7				
8				
				Total:

Basal Area Worksheet (Key)

Forest A

American Beech	4,000 – 4,600 cm^2
Bigtooth Aspen	1,900 – 2,200 cm^2
Flowering Dogwood	200 – 300 cm^2
Northern Red Oak	7,500 – 8,300 cm^2
Sugar Maple	3,200 – 3,700 cm^2

Forest B

American Beech	250 - 350 cm^2
Bigtooth Aspen	1,800 – 2,000 cm^2
Flowering Dogwood	125 - 150 cm^2
Northern Red Oak	1,900 – 2,200 cm^2
Sugar Maple	300 – 400 cm^2

Forest C

American Beech	14,000 – 16,000 cm^2
Bigtooth Aspen	0 cm^2
Flowering Dogwood	350 - 450 cm^2
Northern Red Oak	3,500 – 4,000 cm^2
Sugar Maple	14,000 – 16,000 cm^2

Tree Field Guide

American Beech-Sugar Maple Forests of Michigan

American Beech

(*Fagus grandifolia*)

Height: 18-28 meters (60-90 feet).

Age: 300-400 years old.

Shade-Tolerance: Very Tolerant.

Key Characteristics: Thin, smooth, gray bark. Oblong leaves with toothed edges, remaining on young trees in winter.

Fun Fact: Blue jays help beech trees by carrying their seeds long distances.

Bigtooth Aspen
(*Populus grandidentata*)

Height: 18-32 meters (60-110 feet).

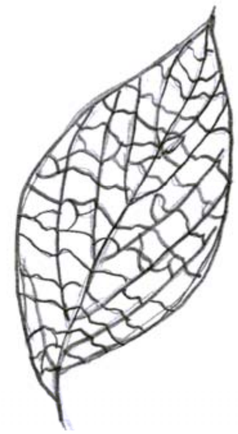
Age: 50-60 years old.

Shade-Tolerance: Very Intolerant.

Key Characteristics: Thin, smooth, gray bark with black wrinkles. Large-toothed, triangular leaves that tremble in breeze.

Fun Fact: Aspen trees provide food for wildlife; beaver eat the bark, and white-tailed deer eat the leaves.

Flowering Dogwood
(*Cornus florida*)



Height: 5-10 meters (16-33 feet).

Age: 100-200 years old.

Shade-Tolerance: Very Tolerant.

Key Characteristics: Blocky, alligator-like bark. Oval leaves clustered and paired opposite each other at tips of branches.

Fun Fact: The dogwood’s leaves break down very quickly on the forest floor, returning nutrients to the soil.

Northern Red Oak
(*Quercus rubra*)

Height: 20-28 meters (65-90 feet).

Age: 300+ years old.

Shade-Tolerance: Midtolerant.

Key Characteristics: Thick brownish bark with vertical ridges. Leaves have lobes with toothed edges.

Fun Fact: Native Americans used the red oak as medicine to treat sore throats and fever, and also as an appetizer.

Sugar Maple
(*Acer saccharum*)

Height: 18-30 meters (60-100 feet).

Age: 200-400 years old.

Shade-Tolerance: Very Tolerant.

Key Characteristics: Dark gray bark with deep vertical ridges. 5-lobed leaves paired opposite each other on branch.

Fun Fact: Trees are tapped in early spring. Approximately 34 gallons of sap are needed to make 1 gallon of maple syrup.

Tree Ranking Worksheet

Directions: Write the name of each tree species on a line next to the appropriate height, age, and shade-tolerance ranking.

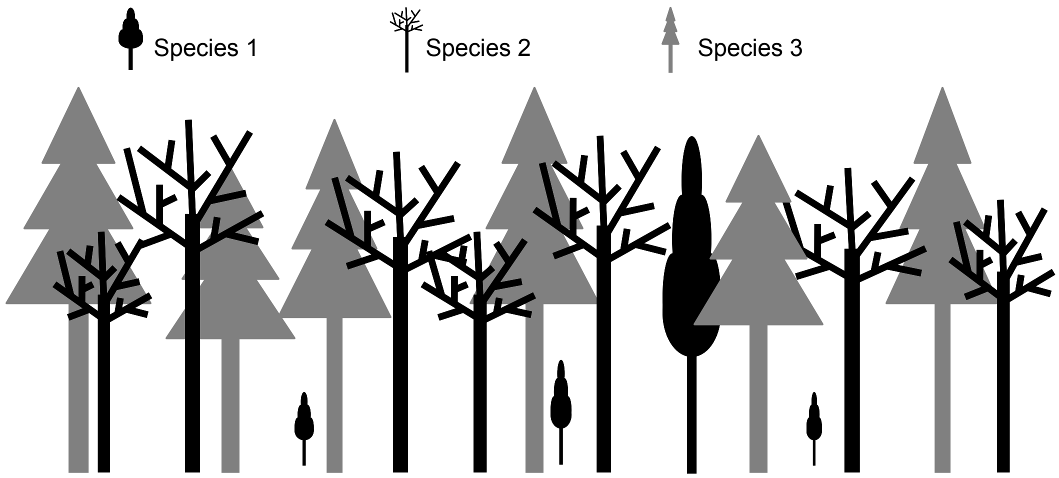
Height		Age		Shade-Tolerance	
	______________		______________		______________
> 15 m	______________	**≥ 100 yrs**	______________	**very tolerant**	______________
	______________		______________		______________
	______________		______________		
					______________
	______________		______________	**midtolerant**	______________
≤ 15 m	______________	**< 100 yrs**	______________		______________
	______________		______________		
	______________		______________		______________
				intolerant	______________
					______________

Tree Ranking Worksheet (Key)

Directions: Write the name of each tree species on a line next to the appropriate height, age, and shade-tolerance ranking.

	Height		Age		Shade-Tolerance
> 15 m	American Beech Bigtooth Aspen Northern Red Oak Sugar Maple	**≥ 100 yrs**	American Beech Northern Red Oak Sugar Maple Flowering Dogwood	**very tolerant**	American Beech Flowering Dogwood Sugar Maple
				midtolerant	Northern Red Oak
≤ 15 m	Flowering Dogwood	**< 100 yrs**	Bigtooth Aspen		
				intolerant	Bigtooth Aspen

Quiz

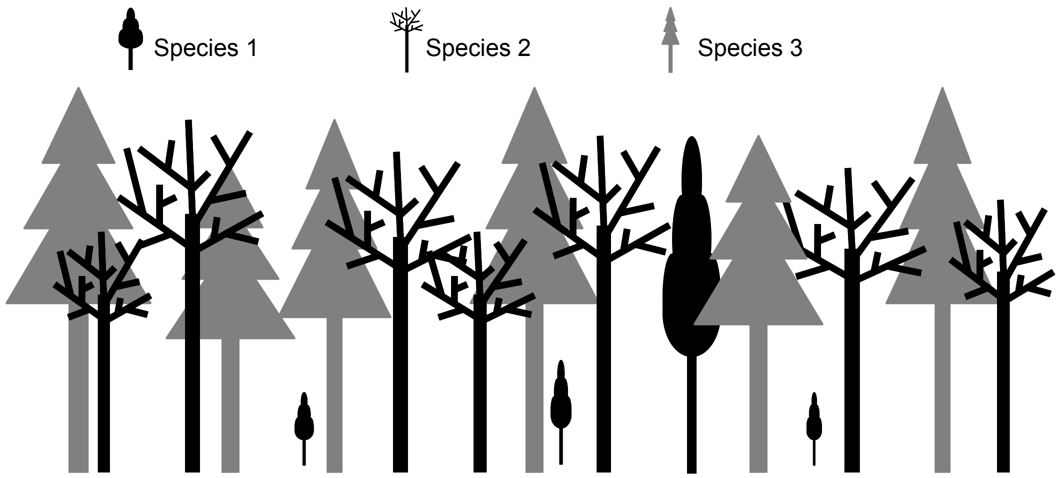


(1) Describe the community structure of the forest above, using the relevant ecological terms.

(2) Define succession in general, and describe the probable path of succession for the forest above. Explain your reasoning.

(3) Explain the role of disturbance in succession, and describe the difference between primary and secondary succession? Provide an example of each type.

Quiz (Key)



(1) Describe the community structure of the forest above, using the relevant ecological terms.

Answer: The community is composed of species 1, 2, and 3 (species composition), although species 2 and 3 have the highest species abundance. The physical structure of the community includes a canopy layer consisting almost entirely of species 2 and 3, and an understory containing only species 1. In addition, species 2 and 3 almost certainly have the largest biomass among the species of the forest. Clearly, species 2 and 3 are currently the dominant species in this community.

(2) Define succession in general, and describe the probable path of succession for the forest above. Explain your reasoning.

Answer: Succession is a change in community structure over time, including changes in species composition, species abundance, physical structure, and dominant species. Species 1 is likely to dominate the forest above in the future. It is the only species reproducing in the understory (apparently shade-tolerant), and has the ability to grow into the canopy layer based on its current presence there. In the absence of a major disturbance, the climax of this forest will consist of species 1.

(3) Explain the role of disturbance in succession, and describe the difference between primary and secondary succession? Provide an example of each type.

Answer: Disturbance is the destruction or removal of species in a community. A major disturbance initiates the process of succession in a community. Primary succession follows a disturbance that destroys all species, as well as removing the soil layer. Dune succession is an example of primary succession. Secondary succession follows a disturbance, such as fire or logging, that leaves the soil layer intact.